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Research report

Attitudes, perceptions, and trust. Insights from a consumer survey regarding genetically modified banana in Uganda☆

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ABSTRACT

Genetically modified (GM) crops and food are still controversial. This paper analyzes consumers' perceptions and institutional awareness and trust toward GM banana regulation in Uganda. Results are based on a study conducted among 421 banana-consuming households between July and August 2007. Results show a high willingness to purchase GM banana among consumers. An explanatory factor analysis is conducted to identify the perceptions toward genetic modification. The identified factors are used in a cluster analysis that grouped consumers into segments of GM skepticism, government trust, health safety concern, and food and environmental safety concern. Socioeconomic characteristics differed significantly across segments. Consumer characteristics and perception factors influence consumers' willingness to purchase GM banana. The institutional awareness and trust varied significantly across segments as well. The findings would be essential to policy makers when designing risk-communication strategies targeting different consumer segments to ensure proper discussion and addressing potential concerns about GM technology.

Introduction

The world's area planted in genetically modified (GM) crops has increased substantially over the past 10 years. Approximately 134 million hectares were planted with GM crops in 2009, and 46 percent of them were in developing countries (James, 2009). Argentina, Brazil, China, India, and South Africa contributed approximately 40 percent of the global total, or 46 million hectares (James, 2008). In Africa only Burkina Faso, Egypt, and South Africa have commercialized GM crops, while Kenya, Nigeria, and Uganda have GM crops under confined field trials (Karembu, Nguthi, & Ismail, 2009). Ghana, Mozambique, and Tanzania also have ongoing GM crop research activities, particularly on food staples (Karembu et al., 2009). With these developments, some experts predict that by 2050 GM crops will be cheaper than other crops, be readily available, and have the potential to increase yields and yield stability of staple food crops (FAO, 2009).

In spite of the potential of GM crops to increase food security in developing countries, their adoption is still negatively affected by public opinion, including anti-GM lobby groups (Qaim, 2009). The major public concerns are the potential negative effects on the environment and human health (FAO, 2004). Environmental risks such as gene flow, evolution of resistance in the targeted pest population, impacts on nontarget organisms, and food safety are often raised (Qaim, 2009; Smale & De Groote, 2003). Several studies have been conducted to assess consumer attitudes and perceptions toward GM crops (Bett, Ouma, & De Groote, 2010; Curtis, McCluskey, & Wahl, 2004; Govindasamy, Onyango, Hallman, Jang, & Puduri, 2004; Kimenju & De Groote, 2008; Kushwaha, Musa, Lowenberg-DeBoer, & Fulton, 2008; Mucci, Hough, & Ziliani, 2004; Onyango, Govindasamy, Hallman, Jang, & Puduri, 2006). Results reveal that consumers' perceptions toward the potential benefits and risks of GM crops are still mixed and differ within and across countries. Moreover, consumer attitudes toward GM crops change as consumers are exposed to new information (Smale et al., 2009). Hence, information has a crucial impact on consumers' preferences for GM food products. Smale et al. (2009) also highlight that in developing countries there is a general lack of empirical studies integrating consumers' preferences with farmers' adoption of GM crops: that is, linking the propensity to purchase and the propensity to adopt in one study.

A study of urban consumers in Kenya revealed that even though GM maize would be widely accepted (68 percent), consumers were also concerned about potential impacts on biodiversity and

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nontargeted insects (Kimenju & De Groote, 2008). Bett et al. (2010) report that the Kenyan food industry gatekeepers (that is, millers and supermarket managers) generally appreciated the potential benefits for GM maize, but also expressed concerns about environmental, human, and animal health safety. In northern Nigeria, ethical concerns about the GM technology were also found to be important factors in determining whether a consumer accepts GM technology or not (Kushwaha et al., 2008). While these studies address the issue of perception of GM products from urban consumers who are mostly solely consumers, there is lack of research on the side of producers who are also consumers of staple crops. This important issue is now analyzed using GM banana[1] in Uganda as an empirical example. This study links both sides of the market for a major food staple by incorporating farmers as consumers (adopters) with nonproducing consumers (sole consumers) in order to examine their opinions toward the introduction of GM banana in Uganda. Moreover, a few previous applied ex ante studies have investigated the determinants of the potential demand/supply for improved traits of banana varieties (for example, GM banana) in Uganda (Edmeades & Smale, 2006; Edmeades, 2007). These studies used data collected from banana-producing households but did not include consumers' attitudes and perceptions[2] toward GM banana.

The GM banana is the pioneer staple food crop in Uganda developed through modern biotechnology. Different transgenic traits are being developed.[3] These include, among others the trait resistant to the air-borne fungal black leaf spot disease, or "black Sigatoka" (*Mycosphaerella fijiensis*), and a nutritional enhancement trait (enhanced carotenoid content). The bananas chosen for modification are local cooking bananas, because they are the most widely grown and are highly preferred by consumers. There are many staple crops in Uganda, but modern biotechnology research was pioneered with banana due to a number of reasons. First, the modern biotechnology innovations target economically important biotic constraints that cannot be easily addressed through conventional breeding (De Vries & Toenniessen, 2001). Second, bananas pose little risk of jeopardizing trade through exports to countries or regions that do not accept transgenic products, such as the EU (Nielsen, Thierfelder, & Robinson, 2001). East African highland cooking bananas are mostly produced and consumed locally, with little regional trade and negligible exports. Third, GM bananas have a real potential for making a difference in smallholders' welfare as a source of food and/or income (Smale, 2007).

Smale and De Groote (2003) discuss the potential risks of GM banana such as gene flow, resistance evolution in targeted pest populations (due to genetic uniformity), health, and nontarget species effects. The authors highlight the existence of limited scientific evidence on the effects of GM banana on human health, gene flow, and nontarget species. Due to its biological characteristics, scientists expect that the risk of pollen flow in a GM banana is no different than with a conventional variety. Thus the impact of gene flow is considered to be insignificant. The low probability of pollen flow reduces impact on nontarget species as well, although this biosafety issue still needs further study. The food and feed safety of the existing GM banana remains to be confirmed.

Another concern has been the potential loss of genetic diversity with the introduction of GM banana (FAO, 2001). As people's preferences change, the less productive clones are abandoned, which would result in limited varietal diversity. However, this is no different than the release of a conventionally bred banana, thus there may be less of a concern from a regulatory standpoint. Still, these concerns may raise questions about the safety of GM banana varieties after deliberate release. In this context, risk assessment is vital before a decision to release GM banana is made. Even if GM banana and other GM products are proven safe for human health and the environment, consumer concerns may continue to play a significant role in the dissemination of these technologies in Uganda and other countries (Paarlberg, 2008). The risk assessment may not meet the consumers' needs for food safety, which may influence their decision on whether to accept or reject GM banana. Studies of consumer attitudes and behavior are therefore crucial for determining the potential economic impact of such crops but also for designing governance structures for their introduction. This is important as the new GM banana varieties can substantially increase farm household income (Kikulwe, Wesseler, & Falck-Zepeda, 2008) and reduce, via higher yields per hectare, the environmental footprint of agriculture production (Wesseler, Scatasta, & Fall, 2011).

Given the significance of this subject, a better understanding of consumers' opinions toward the introduction of GM banana in Uganda is desirable to improve government policies toward GM crops, which in turn could increase consumers' trust and confidence in safe GM products. In addition, assessing consumer attitudes and perceptions in this study will contribute to the understanding of the extent of concerns about GM organisms in a heterogeneous banana industry, which includes 84 different cultivars or clones (Karamura, 1998) of the East African highland banana common in Uganda. Specifically, four objectives are addressed in this study: (1) to investigate consumers' willingness to purchase GM banana and factors influencing consumer purchasing behavior; (2) to identify and classify consumers' attitudes and perceptions toward GM banana, and analyze factors influencing them; (3) to identify the relationship between the three transgenic trait types and consumers' intentions to purchase a GM banana; and (4 to determine consumers' awareness and trust in organizations involved in the regulation and control of production, sale, and release of foods, beverages, and seeds in Uganda.

The analysis considers three first-generation transgenic banana traits: (1) an agronomic trait possessing disease-resistance that could lead to more farm production; (2) a nutritional trait enhanced with direct nutritional benefits; and (3) a taste trait that has been modified to improve taste. One of our a priori expectations is that our sample will be composed of different consumer segments, based on their perceptions and attitudes toward risks and benefits of GM food. We also hypothesize that farmers have heterogeneous preferences regarding crop choices that depend on economic and socioeconomic factors that are well documented in the literature. Those preferences are likely to affect the willingness to purchase as well as the likelihood of adoption. The willingness to purchase by sole consumers, as well, can be

[1] The GM bananas being developed in Uganda are all transgenic. In this paper we use GM banana to refer to transgenic GM banana.

[2] Attitudes and perceptions are closely linked and we do not treat them separately in this article. Attitudes are usually defined as a disposition or tendency to respond positively or negatively toward a certain thing (idea, object, person, or situation) such as a GM banana; they are closely related to opinions and beliefs and are based upon experiences. Perception is the process by which a person attains awareness or understanding of its environment by organizing and interpreting sensory information such as information about GM banana (Pomerantz, 2003). In this context, for example, risk and benefit perceptions may influence consumers' attitudes toward GM banana, which in turn, are determined by other general attitudes and knowledge concerning GM food as a whole, as has been discussed by other scientists (see e.g. Verdurme & Viaene, 2003).

[3] These traits are being developed by the National Agricultural Research Organization (NARO) of Uganda, the University of Leuven-Belgium, the University of Queensland-Australia, and the Agricultural Biotechnology Support Program 2 (ABSPII) at Cornell University-United States of America. A number of agronomic traits are targeted, but only two (black Sigatoka-resistant trait and Banana *Xanthomonus* Wilt-resistant trait) have reached the advanced stage of confined field trials. Nutritional traits target enhancement of the vitamin A and iron; GM bananas with this trait are currently undergoing confined field trail assessment. For the taste trait, so far no work has been done; but we included it in the study to see whether consumers mind about taste improvement or not.

expected to depend on differences in income, education, age, and other household characteristics. On the one hand, sole consumers may assign higher utility values to high quality and more nutritious banana, in a manner similar to that seen by Loureiro and Bugbee (2005), Lusk, Jamal, Kurlander, Roucan, and Taulman (2005), and González, Johnson, and Qaim (2009). On the other hand, they may be more concerned about the future health risks of GM crops (food), which would negatively influence their willingness to purchase. We test these hypotheses on data collected from 421 banana-producing and consuming households in rural and urban areas using factor analysis, cluster analysis, and nonlinear estimation approaches. The remainder of the paper is organized as follows. The methodology, including data collection and analysis, is described in the next section. Third section presents and discusses the results and the conclusions drawn from this study.

Methods

Data collection

Data was generated from a survey conducted in three administrative regions, Eastern, Central, and Southwestern Uganda, comprising three distinct agro-ecological zones where cooking bananas (green banana) are produced and consumed. The study was implemented in July and August 2007 with face-to-face interviews. Six enumerators were hired and trained specifically for this study. In executing the survey, enumerators briefly described the context of the study and informed the respondents that there are no wrong or right answers but their opinions were of interest. Using a multi-stage sampling procedure, a total of 421 respondents were randomly selected for this survey using the then current community listings from 21 randomly selected communities, allowing to draw general conclusions. In cases where the preselected respondent was not available, a replacement was picked from the same community listing. Data was collected using a formal pre-tested questionnaire. Data collected, in order, included: household characteristics, consumer's purchasing behavior, consumer's attitudes and perceptions toward GM banana, consumer's institutional awareness and trust in organizations involved in regulation, distribution, sale, consumption of food, beverages, and planting material, and market participation.

The survey collected data concerning consumers' purchasing behavior. Respondents were first asked to rate five product characteristics – price, taste, nutrition, health safety, and environmental safety – according to their level of importance in purchasing food. The rating for each characteristic was based on a five-point Likert scale, including strongly disagree (1), disagree (2), uncertain (3), agree (4), and strongly agree (5). We measured willingness to purchase using a 5 point Likert scale, which was later condensed to three (agree, uncertain and disagree) at analytical level. Consumers' attitudes and perceptions were then measured by asking respondents if they strongly agreed or disagreed with 22 statements. All responses were rated using the same Likert scale. The survey elicited additional data on consumers' awareness and trust in organizations handling regulation and control of production and sale and release of the aforementioned crops. To understand the level of awareness of the organizations involved in the regulation and control of production and the sale and release of foods, beverages, and seed, each respondent was requested to indicate whether s/he knew or heard of each of the mentioned institution ("Awareness"). For known or heard of organizations, each respondent was asked to complete the subsequent three trust questions: (1) do you have confidence that the named institution can control production of food or crops that could be harmful to people ("Trust/not produce")? (2) Do you have confidence that the named institution can prevent harmful products to be sold in shops, supermarkets, and restaurants ("Trust/not sell")? (3) Do you have confidence that the named institution can control release of crops that could be harmful to the environment ("Trust/not release")? Each question had three alternatives, "yes" (if trust in an institution), "no" (if not trusted), and "don't know" (if a respondent is not certain). Finally, respondents were asked about their socioeconomic characteristics, including age, education, income, household size, and market participation. Market participation was measured as whether or not a respondent sells and/or buys banana.

Data analysis

Data are analyzed using the statistical package Stata, version 11. The willingness to purchase and factors affecting purchase were compared with socioeconomic characteristics. For the perception and attitudinal questions, which tend to overlap and can reflect more than one motivational concern toward GM food and crops, various approaches were used. First, a principal factor analysis with Crawford–Ferguson rotation was performed to develop scales based on linear combinations of statement responses that have similar patterns of variation. The criteria for acceptability of a factor solution were based on (1) a minimum factor membership of four items[4]; (2) exclusion of items with factor loadings less than 0.40, following Kontoleon (2003) and Birol, Villalba, and Smale (2009); and (3) minimum factor eigenvalues of 1.0. This was followed by a reliability analysis based on Cronbach's alpha (one of the measures of reliability) coefficients to ensure internal reliability of the factors. Next, a two-stage (nonhierarchical and K-means) cluster analysis was employed to identify clusters of respondents with similar views about the GM food (crops). Doing so allows one to minimize within-cluster variance and maximize between-cluster variance (Jansen, Damon, Pender, Wielemaker, & Schipper, 2003), as is widely done in consumer perception studies, for example, Arvanitoyannis and Krystallis (2005), Onyango et al. (2006), Kaye-Blake, O'Connell, and Lamb (2007), and Zhang, Huang, Qiu, and Huang (2010). Based on the factor scores of each respondent, a nonhierarchical cluster analysis was performed using a K-means-cluster analysis. In order to better understand the profiles of the clusters, ANOVA tests were applied to relate the mean values of the clusters with the consumers' socioeconomic characteristics. To explain the cluster membership, a multinomial regression analysis was estimated using socioeconomic variables. In addition, the marginal effects for each explanatory variable were estimated to explain the change in the probability of belonging to any cluster given a marginal change in the explanatory variable. Finally, factors affecting the willingness to purchase GM banana (food) were analyzed using multinomial regressions on a categorical variable ("would not purchase," "indifferent," and "would purchase") as the dependent variable. The explanatory variables included the perception factors obtained from the factor analysis and the socioeconomic characteristics of the consumer.

To analyze the level of awareness of and trust in the organizations involved in regulation and control of production and the sale and release of foods, beverages, and seed, each question had three alternatives: "yes," "no," and "don't know." The organizations were grouped by category: leadership, extension service, research and education, government-owned ministries and parastatals, private sector, and nongovernmental organizations. For each category an institution index was calculated: responses were given scores or weights (−0.5 for "no," 0 for "don't know." and 0.5 for "yes"). Average scores were calculated for each

[4] Fabrigar, MacCallum, Wegener, and Strhan (1999) recommend that for the explanatory factor analysis results to be more accurate, it is sensible to include at least four measured variables for each common factor.

institutional category by taking the mean of the organizations in that category. ANOVA tests were applied to relate the mean score value of these organizations with the identified clusters.

Results and discussion

Sample characteristics

The socioeconomic characteristics of the sample are presented in Table 1a. More male respondents (56.7 percent) answered than females (43.2 percent). Respondents' average age is 40.8 years (varying from 18 to 92 years); persons younger than 18 were not selected for the interviews. The mean number of years of formal education of the respondents is 7.2, with only approximately 10 percent of the respondents having college or university education. The average household size in the sample is 6.1. The average monthly household income was approximately UGX 195,000 (or $111). Nearly a half of the households were located in the Central Region, while the Eastern and South-western Regions shared the rest equally. Approximately a third of the households were located in the urban areas of the three selected regions. The average banana plantation size is about 0.45 hectares, with approximately a third of the sampled households selling banana and close to two-thirds buying banana. In general, only a fifth (20 percent) of the sampled households was found to be sole consumers, compared to approximately 80 percent who were both producers and consumers (adopters).

Social and economic characteristics of adopters and sole consumers differ significantly as reported in Table 1b. Sole consumers were mainly located in urban areas of the Central Region, while adopters were mostly located in rural areas and somewhat equally distributed among the three Regions (Central, South-western and Eastern). The age of the respondent differs significantly, with adopters being older than the sole consumers. Sole consumers on average have more years of formal education than the adopters. The size of the household differs significantly between the two groups, with larger households common among adopters. A significantly higher percentage of sole consumer households have at least one member of the household working off-farm; they have a significantly higher income compared to the adopters.

Table 1a
Socioeconomic characteristics of respondents.

Characteristic	Sample
Female respondent (%)	43.2
Average age (years)	40.80 (15.35)
Average education of respondent (years)	7.20 (4.47)
Education levels (%)	
Never	12.4
Primary	49.6
Secondary	28.3
College/University	9.7
Number of household members	6.10 (6.11)
Monthly household income (UGX)[a]	194,748.80 (351,179.00)
Regional distribution of the sampled households (%)	
Eastern Region	28.5
Central Region	43.0
Southwestern Region	28.5
Location of the households (%)	
Rural	66.7
Urban	33.3
Area under banana production (hectares)	0.45 (0.71)
Household selling banana (%)	35.1
Households buying banana (%)	58.9
Household consumption status (%)	
Both producers and consumers (adopters)	80.3
Sole consumers	19.7

[a] The average exchange rate between July and August was US$ = UGX 1750. Standard deviations are in parentheses.

Table 1b
Characteristics of adopters and sole consumers.

Variable	Adopters	Sole consumers	*t*-Test
Location dummy (urban = 1)	0.20 (0.40)	0.85 (0.35)	−14.59***
Female respondent	0.39 (0.49)	0.61 (0.49)	−3.552***
Age in years	42.39 (15.52)	34.29 (12.76)	4.96***
Education in years	6.75 (4.31)	9.08 (4.65)	−4.15***
Household size	6.40 (3.33)	4.93 (2.80)	4.12***
Monthly income	174,584.10 (341,029.3)	276,865.50 (381,055.3)	−2.24**
Employed off-farm	0.47 (0.50)	0.78 (0.41)	−5.90***
South-western region	0.33 (0.47)	0.12 (0.33)	4.65***
Central region	0.39 (0.49)	0.60 (0.49)	−3.57***
Eastern region	0.28 (0.45)	0.28 (0.45)	0.18

Note: Standard deviations are in parentheses.
** Significance at 0.05 level.
*** Significance at 0.01 level.

Factors influencing food-purchasing behavior and willingness to purchase a GM banana

To determine the most important factors that influence choice, consumers were asked to rate five product characteristics – price, taste, nutrition, health safety, and environmental safety – according to their level of importance prior to purchasing banana, using a Likert scale ranging from strongly disagree (1) to strongly agree (5). The definition of the "most important factor" was defined by the number of consumers responding to the top (4–5) scale levels, that is, agree and strongly agree. Figure 1 shows the results.

Results show that on average, taste (89 percent), price (76 percent), and nutrition (62 percent) are the most important product factors, while health and environmental safety are the least. This suggests that price and quality (measured as taste and nutrition) are the most important factors positively influencing consumer choice when shopping for cooking bananas in Uganda. The ANOVA tests of the socio-demographic variables (age, gender, education, and income) with the five factors yielded only two significant differences – income on price and gender on taste, as shown in the Appendix A. Also, the chi square tests of the consumer types (sole consumer vs. adopters) with the five factors produced three significant differences (nutrition, health and environment), with taste and nutrition as the more important factor for sole consumers compared to adopters who consider the environmental factor as more important (Appendix B).

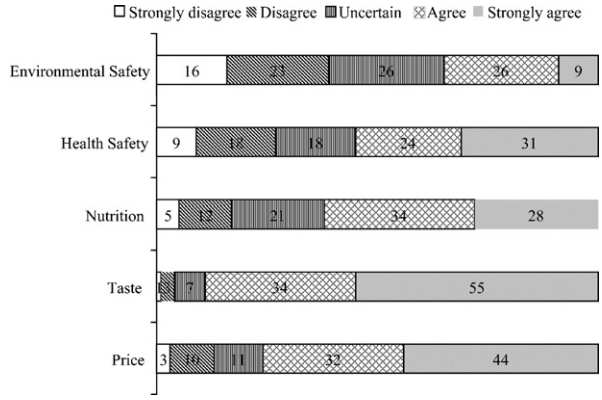

Fig. 1. Factors influencing consumer purchasing behavior for cooking banana (percent).

Table 2
Factor analysis loadings for consumers' Answers to perception and attitudinal statements.

No.	Statements were obtained using a five-point Likert scale ranging from strongly disagree to strongly agree	Agree or strongly agree (%)	Factor loadings for perceptions		
			Benefit	Food and envir. risk	Health risk
1	I would buy GM banana bunch if it was sold at the same price as a non-GM banana bunch, but was much more nutritious.	92	**0.73**	−0.16	−0.30
2	I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but tasted better.	90	**0.70**	−0.17	−0.32
3	I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but was produced with fewer pesticides.	78	**0.57**	−0.17	−0.29
4	I would buy a GM banana bunch if it was cheaper than a non-GM banana bunch.	79	**0.56**	−0.24	−0.31
5	If the majority of the Ugandan people are in favor of GM food, it should be legalized.	87	**0.49**	0.16	−0.13
6	I would buy a GM banana bunch if it were more expensive than a non-GM banana bunch	39	0.34	−0.21	−0.11
7	Information about food safety and nutrition on food labels can be trusted.	51	0.27	0.14	−0.15
8	The government effectively monitors the correct use of GM in the medical, agricultural, and other sectors.	69	0.24	−0.21	−0.05
9	I think the additives in food are not harmful to my health.	57	0.24	0.12	−0.07
10	The risks associated with GM food (if any) can be avoided.	82	0.18	0.10	−0.08
11	When humans interfere with nature, disastrous consequences result.	25	0.05	**0.61**	0.07
12	Among the risks we presently face, those impacting food safety are very important.	64	−0.03	**0.55**	−0.18
13	If something went wrong with GM food, it would be a global disaster.	92	0.00	**0.51**	0.22
14	The government should spend more money to increase food safety.	83	0.29	**0.50**	0.05
15	Humans are harshly abusing the environment.	54	0.02	**0.50**	0.17
16	Pesticides and fertilizers are dangerous to our environment.	74	−0.11	**0.40**	0.10
17	We can only eradicate the diseases and pests that attack crops using GM technology.	48	0.26	−0.32	0.02
18	Harmful environmental effects of GM crops are likely to appear in the distant future.	36	0.18	0.11	**0.66**
19	Harmful human health effects of GM foods are likely to appear in the distant future.	35	0.15	0.08	**0.62**
20	Even though GM food may have advantages, it is basically against nature.	36	−0.05	0.13	**0.41**
21	Eating GM food would harm me and my family.	26	−0.08	−0.07	**0.41**
22	GM technology should not be used even for medicinal purposes.	27	−0.11	−0.12	0.36
	Percent of variance explained (93 percent)		36	30	27
	Cronbach's alpha (α) coefficient		0.79	0.62	0.60

Note: Loadings in bold are values of 0.4 and above.

Next, consumers were asked to indicate their willingness to purchase a GM banana if offered (1) at the same price, but with enhanced nutrition (vitamin and iron), reduced pesticide use and better taste; (2) at a lower price; and (3) at a higher price (Fig. 2). If GM banana is sold at the same price as non-GM banana, results indicate that consumers' willingness to purchase GM banana is very high (ranging from 78 to 92 percent, that is, "agree" and "strongly agree" responses). Similarly, over three-quarters (78 percent) of the consumers were willing to purchase GM banana at a lower price. But only slightly more than a third (39 percent) would buy GM banana if a higher price is charged. This indicates a high acceptance of GM banana at a lower price but reduces to half if offered at a higher price.

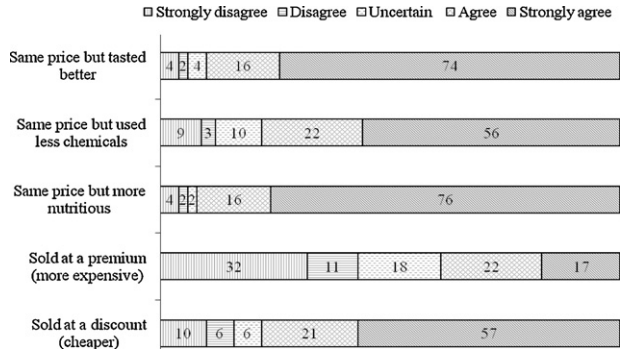

Fig. 2. Consumers' willingness to purchase GM banana at the same price, at a higher price, or at a lower price compared to the traditional (non-GM) banana. *Notes*: The exact wordings for the questions used are as following: "I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but tasted better"; "I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but was produced with fewer pesticides"; "I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but was much more nutritious."; "I would buy a GM banana bunch if it were more expensive than a non-GM banana bunch"; and "I would buy a GM banana bunch if it were cheaper than a non-GM banana bunch." Numbers represent the percentages of respondents.

Interestingly, more than three-quarters of respondents were willing to purchase GM banana with tangible benefits – for example, more vitamins and iron (nutritional enhancement trait), less pesticide application (agronomic trait), and better taste (taste trait) – sold at the same price as the non-GM banana. These results are similar to the findings of Kimenju and De Groote (2008), who found that most consumers (68 percent) were willing to buy GM maize meal at the price of their favorite maize meal in Nairobi, Kenya.

Factor analysis

While the previous information indicates that taste, price, and nutrition are important, it does not provide a detailed picture about consumers' attitudes and perceptions. Consumers were asked about their perceptions and attitudes toward GM banana. A factor analysis was done to group overlapping attitudes and perceptions. Results indicate that the most appropriate solution involved three factors (Table 2) and a comparison analysis revealed that the extraction of three factors was in accord with the standard acceptability criteria. The scree test[5] and the number of eigenvalues greater than one support the decision to accept a three-factor solution. An orthogonal Crawford–Ferguson rotation specifying a three-factor solution accounted for 93 percent of the common variance – with factor 1 accounting for 36 percent, factor 2 for 30 percent, and factor 3 for 27 percent – suggesting that each factor represents an important indicator of consumer attitudes and

[5] A scree test is a plot of eigenvalues against the generated factors. It is a visual inspection used to determine the number of factors to be retained. The number of factors to be retained corresponds to the eigenvalue where the slope changes quickly (the eigenvalue preceding the scree) (Cattell, 1966).

Table 3
Percentage of cases in each cluster.

Cluster names	Percentages
GM skepticism (GMS)	8 (34)
Government trust (GT)	27 (114)
Health safety concern (HS)	29 (123)
Food and environmental safety concern (FES)	36 (150)

Note: Numbers in parentheses represent the number of respondents.

perceptions. Cronbach's alpha (α) coefficients were computed to give an indication of the internal consistency of each factor, a measure of reliability. Values were found to be moderate to high ($\alpha \geq 0.6$), displaying the homogeneity of each factor.

Factor naming was based on variables that factored together and the relative magnitude of the loadings in absolute terms. The first factor, "benefit perception," had high loadings on questions related to approval and potential benefits of GM crops. This category of attitudes and perceptions captures the tendency of a consumer to support a GM food crop based on its various potential benefits (for example, price, nutrition, less chemical use, and taste). The second factor, "food–environment risk perception," had high loadings on statements that reflected consumer concerns on food and environmental safety. The food–environment risk perception refers to concerns over the impact of GM food on food and environmental safety and concerns about human interference with nature. The third factor, which had high loadings on health safety, was called "health risk perception." Health risk perception reflects concerns over the likely – long-term but unknown – effects of GM food on health safety in general. Factor scores for each factor were obtained for each household, which were then used to classify the respondents based on their attitudes and perceptions. A comparison analysis of perception factors among the consumer groups only showed significant differences for the health perception factor, with sole consumers scoring higher for the unknown health concerns of the technology compared to adopters (Appendix C).

Classification by consumers' attitudes and perceptions toward GM banana (food)

To identify different consumer classes derived from their attitudes and perceptions toward GM banana, a cluster analysis was run based on the factor scores that were generated from the previous factor analysis. The number of clusters to be generated was identified using the Calinski and Harabasz (1974) pseudo-F index (Calinski stopping rule) (Milligan & Cooper, 1985). The pseudo-F index increased as more clusters were added, but minimized after the fourth cluster. Based on this criterion, four clusters were considered appropriate. The four identified clusters and the number of cases in each cluster is given in Table 3. The four clusters carry cluster memberships of 8 percent, 27 percent, 29 percent, and 36 percent, respectively. In order to further test the validity of the four clusters, an ANOVA test was performed. The test indicates all results attaining a 1 percent significance level, indicating satisfactory and robust results of our classification.

In order to label the clusters, we used both the original questions and the results of the factor analysis. First, we calculated the sample and clusters means based on the raw data of the attitudinal and perception statements, as presented in Table 4. Given the large number of statements (22), it was not easy to assign a label based on individual statements. We then focused on differences between group means. Cluster 1 had the lowest scores for the potential benefits of the GM technology (statements 1, 2, 3, 4, and 6). Thus the label "GM skepticism" was preferred. The mean scores for clusters 2, 3, and 4 were somewhat similar and were supporters to the potential benefits of the GM technology, including GM banana (food). However, they differed in some risk-related statements. Cluster 2 was the most neutral among the three and had the highest level of trust and confidence that government effectively monitors the correct use of GM technology in the medical, agricultural, and other sectors (statement 8). Cluster 2 was therefore labeled "government trust." Cluster 3 paid a higher attention to health risk statements compared to cluster 4

Table 4
Cluster means for attitudinal and perception statements.

No.	Attitudinal statements	Clusters				Full sample
		GMS	GT	HS	FES	
1	I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but was much more nutritious.	2.03	4.8	4.66	4.89	4.56
2	I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but tasted better.	1.76	4.82	4.58	4.89	4.53
3	I would buy a GM banana bunch if it was sold at the same price as a non-GM banana bunch, but was produced with fewer pesticides.	1.76	4.56	4.07	4.41	4.14
4	I would buy a GM banana bunch if it was cheaper than a non-GM banana bunch.	1.62	4.61	3.98	4.39	4.10
5	If the majority of the Ugandan people are in favor of GM food, it should be legalized.	2.88	4.03	4.31	4.64	4.23
6	I would buy a GM banana bunch if it were more expensive than a non-GM banana bunch	1.29	3.17	3.00	2.69	2.79
7	Information about food safety and nutrition on food labels can be trusted.	2.62	3.17	3.12	3.67	3.29
8	The government effectively monitors the correct use of GM in the medical, agricultural, and other sectors.	3.06	3.82	3.77	3.46	3.61
9	I think the additives in food are not harmful to my health.	3.12	3.18	3.46	3.75	3.46
10	The risks associated with GM food (if any) can be avoided.	4.35	3.28	4.01	4.71	4.09
11	When humans interfere with nature, disastrous consequences result.	1.82	2.93	3.02	1.41	2.33
12	Among the risks we presently face, those impacting food safety are very important.	4.09	2.90	3.88	4.06	3.69
13	If something went wrong with GM food, it would be a global disaster.	4.03	2.85	4.48	4.85	4.41
14	The government should spend more money to increase food safety.	4.56	3.36	4.53	4.63	4.23
15	Humans are harshly abusing the environment.	2.44	3.75	3.87	3.17	3.47
16	Pesticides and fertilizers are dangerous to our environment.	4.50	3.39	4.01	4.23	3.96
17	We can only eradicate the diseases and pests that attack crops using GM technology.	2.62	2.94	3.12	3.53	3.18
18	Harmful environmental effects of GM crops are likely to appear in the distant future.	3.18	2.54	3.85	2.87	3.09
19	Harmful human health effects of GM foods are likely to appear in the distant future.	3.26	2.55	3.76	2.77	3.04
20	Even though GM food may have advantages, it is basically against nature.	3.41	2.50	3.57	2.71	2.96
21	Eating GM food would harm me and my family.	2.85	2.31	3.34	2.01	2.55
22	GM technology should not be used even for medicinal purposes.	2.74	2.37	3.15	1.87	2.45

Note: All attitudinal statements were obtained using a 5-point Likert scale as follows: 1. strongly disagree; 2. disagree; 3. neither agree nor disagree; 4. agree; 5. strongly agree. GMS = GM skepticism; GT = government trust; HS = health safety concern; FES = food and environmental safety concern.

Table 5
Characteristics of the consumer groups identified through cluster analysis.

Perceptions	Consumer clusters				*F*-statistic
	GMS	GT	HS	FES	
	Mean factor scores (standard deviations)				
Benefit	−2.38 (0.81)	−0.06 (0.43)	0.36 (0.43)	0.36 (0.43)	342.68***
Food and environment	0.54 (0.73)	−0.92 (0.64)	−0.17 (0.59)	0.67 (0.42)	187.30***
Health	0.72 (0.82)	−0.52 (0.54)	0.83 (0.47)	−0.49 (0.47)	179.73***

Note: Values in the table are means of the factor scores, and values in parentheses are standard deviations. The *F*-statistics are from ANOVA of intercluster differences. GMS = GM skepticism; GT = government trust; HS = health safety concern; FES = food and environmental safety concern.
*** Significance at less than the 1% level or better.

(statements 18–22). Cluster 3 was named "health safety concern." Cluster 4 was named "food and environmental safety concern," as respondents scored higher for their concerns regarding environmental safety issues compared to cluster 3 (statements 12, 13, 14, and 16).

The factor mean scores differed significantly across the four clusters as shown in Table 5. The ANOVA tests (*F*-statistics) suggest that there is significant inter-cluster heterogeneity on the importance Ugandan consumers placed on each of the three factors. The four clusters were identified and named to describe the characteristics of each group of consumers, which are reflected by mean factor scores. For the benefit perception, higher positive scores indicate a greater preference for GM food and crops, while negative scores show less preference. In contrast, for food–environment and health perceptions, higher positive values indicate higher levels of concern for food–environmental safety and health safety risks, respectively. But negative scores indicate less concern about food–environmental and health risks. For example, the GM skepticism cluster perceived the lowest score for the benefit factor, and these respondents showed a higher concern of the technology's possible effects on health, food, and environmental safety. Even though these consumers were in the minority (constituting only 8 percent of the sample), they seemed to be very skeptical about GM banana and may oppose GM technology in general. The concerns about risks were higher than the perceived benefits of GM crops. Although the government-trust cluster exhibits from almost neutral attitudes to a perception of benefits derived from GM banana (scored substantially less negative), these respondents appeared not to be concerned with the unknown potential risks of the GM technology. They exhibit the lowest scores for the concerns regarding health, food, and environmental safety. This could be the one reason why they tend to trust in government's potential to monitor the proper use of the technology. Consumers in cluster 3 perceive application of GM technology to be beneficial to improving the banana quality. However, they show a higher concern regarding health-related risks that a technology may generate. The fourth cluster also scored positively for the benefit factor, but with the highest level of concern regarding food and environmental safety issues. Respondents perceive that GM technology may have the potential for improving banana quality, but at the same time they are concerned about negative effects on food and on environmental safety.

Table 6 reports the results of the ANOVA differences across the four clusters. Results show that four socioeconomic factors (education, banana acreage, consumer type, and consumer location) were significantly different across the four clusters. Similarly to other studies – Zhang et al. (2010) and Lin, Somwaru, Tuan, Huang, and Bai (2006) – consumer characteristics such as gender and age did not seem to play a significant role in influencing consumers' opinions toward GM banana. The characteristics were found to be insignificant across the four clusters. The GM skepticism cluster included mostly sole consumers, who had the highest number of years of formal education and were found mainly in the urban areas. The government-trust cluster comprised mostly banana-producing and consuming households, those with the fewest years of formal education, and those located mainly in the rural areas.

In order to explain the cluster membership, a multinomial logit regression was estimated, using the GM skepticism cluster as the base category. Table 7 reports the marginal effects. Respondents in the Central Region are less likely to belong to the GMS cluster but more likely to belong to the HS cluster compared to those from the Southwestern Region. The government-trust members are more likely to be younger with smaller banana acreage and be both producers and consumers. An increase in banana acreage by one unit decreases the probability of belonging to the government-

Table 6
Socioeconomic characteristics by cluster (mean scores).

Variable	Clusters				*F*-statistics
	GMS	GT	HS	FES	
Age (years)	40.80 (15.0)	39.5 (14.2)	40.9 (16.1)	41.7 (15.8)	0.45
Education (years)	8.90 (5.0)	6.50 (4.0)	8.00 (4.7)	6.70 (4.2)	4.48***
Banana acreage (ha)	0.49 (0.62)	0.32 (0.40)	0.44 (0.68)	0.55 (0.91)	2.41*
Female respondent (vs. male)	0.35 (0.48)	0.44 (0.50)	0.41 (0.49)	0.47 (0.50)	0.65
Sole consumer (vs. adopters)	0.29 (0.46)	0.13 (0.34)	0.26 (0.44)	0.17 (0.38)	2.95**
Sell banana (vs. don't)	0.47 (0.51)	0.28 (0.45)	0.39 (0.49)	0.35 (0.48)	1.82
Location (1 = urban)	0.53 (0.51)	0.26 (0.44)	0.41 (0.49)	0.27 (0.44)	4.96***
Household size	6.63 (3.28)	6.63 (3.82)	5.81 (3.11)	5.93 (3.28)	1.45
Eastern Region (vs. Southwestern Region)	0.20 (0.41)	0.35 (0.48)	0.23 (0.43)	0.29 (0.46)	1.67
Central Region (vs. Southwestern Region)	0.35 (0.48)	0.38 (0.49)	0.52 (0.50)	0.41 (0.49)	2.06
Monthly income (UGX)	331,302.70 (608,818.50)	167,773.60 (298,397.30)	187,522.60 (327,979.8)	190,223.30 (324,127.3)	1.98
Off-farm employment (vs. no)	0.65 (0.50)	0.54 (0.50)	0.56 (0.50)	0.47 (0.50)	1.45

Note: GMS = GM skepticism; GT = government trust; HS = health safety concern; FES = food and environmental safety concern. Standard deviations are in parentheses.
* Significance at 0.1 level.
** Significance at 0.05 level.
*** Significance at 0.01 level.

Table 7
Marginal effects of multinomial logit model explaining cluster membership with socioeconomic characteristics of consumers.

Variable	GMS	GT	HS	FES
Female respondent (vs. male)	−0.021 (0.025)	−0.020 (0.044)	−0.032 (0.048)	0.073 (0.052)
Education (years)	0.004 (0.003)	−0.006 (0.005)	0.006 (0.006)	−0.005 (0.057)
Household size	0.003 (0.004)	0.011 (0.006)	−0.003 (0.007)	−0.011 (0.008)
Sell banana (vs. don't)	0.058 (0.055)	−0.073 (0.048)	0.110* (0.066)	−0.095* (0.056)
Age	0.001 (0.001)	−0.003* (0.002)	0.001 (0.002)	0.001 (0.002)
Banana acreage (hectares)	−0.005 (0.021)	−0.121** (0.054)	0.020 (0.036)	0.107*** (0.039)
Sole consumer (vs. adopters)	0.057 (0.055)	−0.140*** (0.050)	0.057 (0.078)	0.026 (0.079)
Location (1= urban)	0.058 (0.050)	−0.068 (0.055)	0.123* (0.073)	−0.112* (0.063)
Eastern Region (vs. Southwestern Region)	−0.045 (0.028)	−0.021 (0.064)	0.059 (0.077)	0.007 (0.075)
Central Region (vs. Southwestern Region)	−0.058** (0.025)	−0.028 (0.056)	0.128** (0.065)	−0.042 (0.061)
Monthly income (UGX)	0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	0.000 (0.000)
Off-farm employment (vs. no)	−0.004 (0.033)	0.048 (0.052)	0.012 (0.051)	−0.056 (0.052)

Note: GMS = GM Skepticism cluster; GT = government trust; HS = health safety concern; FES = food and environmental safety concern. Standard errors are in parentheses. Marginal effects of the explanatory variables on the dependent variable are calculated for a one-unit change holding all other factors constant at their mean, but for dummy variable for a discrete change from 0 to 1.

* Significance at 0.1 level.
** Significance at 0.05 level.
*** Significance at 0.01 level.

trust group by 0.121 and increases the probability of being in the food and environmental safety concern group by 0.107, which is consistent with the descriptive statistics. Those who are located in urban areas, most especially in the Central Region of Uganda, and participate in the market as banana sellers are more likely to be in the health-safety concern group but less likely to be in the food and environmental safety concern group. The food and environmental safety concern group is more likely to be located in rural areas, having on average larger banana fields but not producing enough for sale.

Determinants of willingness to purchase of GM banana (food)

Factors influencing a willingness to purchase GM banana with different traits (agronomic, nutritional, and taste) were analyzed using multinomial logit regressions on the categorical variable (''would not purchase'', ''indifferent'', and ''would purchase'', with the last category as reference). Because of the nonlinearity of the estimator used, interpreting coefficients would be problematic; we therefore report marginal effects in Table 8. Perceptions, both positive and negative, influenced the willingness to purchase.

Table 8
Factors affecting the purchase of gm bananas with different traits sold at the same price as a non-GM banana using multinomial logit regression.

Variable	Agronomic trait			Nutritional trait			Taste trait		
	Would not purchase	Indifferent	Would purchase	Would not purchase	Indifferent	Would purchase	Would not purchase	Indifferent	Would purchase
Location (1 = urban)	0.019 (0.039)	−0.023 (0.044)	0.004 (0.052)	−0.003 (0.017)	0.048 (0.047)	−0.045 (0.039)	−0.021 (0.016)	0.051 (0.032)	−0.031 (0.024)
Female respondent (vs. male)	−0.030 (0.023)	0.028 (0.036)	0.003 (0.038)	−0.036** (0.017)	0.015 (0.019)	0.020 (0.016)	0.038*** (0.009)	0.023 (0.020)	−0.061*** (0.023)
Age	0.000 (0.001)	0.000 (0.001)	−0.001 (0.001)	−0.000 (0.001)	0.000 (0.001)	0.000 (0.000)	−0.001* (0.000)	0.002*** (0.000)	−0.001** (0.000)
Education	−0.005** (0.002)	0.009** (0.004)	−0.004 (0.004)	−0.004** (0.002)	0.005*** (0.002)	−0.000 (0.002)	−0.002* (0.001)	0.007*** (0.002)	−0.006*** (0.017)
Monthly income (UGX)	−0.000* (0.000)	−0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	−0.000*** (0.000)	0.000** (0.000)	0.000** (0.000)	−0.000*** (0.000)	0.000** (0.000)
Household size	0.004 (0.003)	0.006 (0.005)	−0.011* (0.005)	−0.002 (0.002)	0.001 (0.002)	0.002 (0.002)	−0.003 (0.002)	0.002 (0.002)	0.001 (0.002)
Off-farm employment (vs. no)	0.004 (0.026)	0.042 (0.038)	−0.046 (0.042)	−0.004 (0.014)	−0.005 (0.014)	0.009 (0.011)	0.013 (0.009)	0.024 (0.033)	−0.037 (0.035)
Banana acreage	−0.040 (0.025)	−0.089** (0.039)	0.129*** (0.044)	0.045 (0.046)	−0.187** (0.088)	0.143*** (0.053)	0.017*** (0.006)	−0.004 (0.007)	−0.013* (0.007)
Sell banana (vs. don't)	0.018 (0.035)	0.161** (0.063)	−0.179*** (0.060)	−0.020** (0.008)	0.074 (0.047)	−0.054 (0.045)	0.011 (0.010)	0.017 (0.023)	−0.028 (0.025)
Sole consumer (vs. adopters)	−0.034 (0.031)	0.074 (0.068)	−0.041 (0.067)	−0.008 (0.015)	−0.028** (0.013)	0.037*** (0.014)	0.007 (0.018)	0.032 (0.030)	−0.039 (0.039)
Eastern Region (vs. South-western Region)	-0.020 (0.030)	0.045 (0.058)	−0.025 (0.057)	−0.013 (0.011)	−0.005 (0.016)	0.018 (0.017)	0.064*** (0.020)	−0.028** (0.014)	−0.035 (0.021)
Central Region (vs. South-western Region)	0.026 (0.032)	0.032 (0.040)	−0.058 (0.047)	−0.003 (0.011)	0.005 (0.021)	−0.002 (0.020)	0.032*** (0.010)	−0.038*** (0.011)	0.006 (0.012)
Perceived benefit	−0.102*** (0.015)	−0.057*** (0.021)	0.159*** (0.030)	−0.044** (0.019)	−0.026*** (0.009)	0.070*** (0.020)	−0.079*** (0.019)	−0.065*** (0.022)	0.144*** (0.031)
Perceived food and environmental risk	0.035** (0.015)	0.041** (0.017)	−0.076*** (0.022)	0.024 (0.017)	−0.007 (0.009)	−0.018 (0.011)	0.040*** (0.010)	0.010 (0.010)	−0.050*** (0.013)
Perceived health risk	0.069*** (0.017)	0.016 (0.015)	−0.085*** (0.021)	0.010** (0.004)	0.004 (0.010)	0.014 (0.009)	0.040*** (0.010)	−0.009 (0.010)	−0.032 (0.008)

* Significance at 0.1 level.
** Significance at 0.05 level.
*** Significance at 0.01 level.

Higher benefit perceptions increased the likelihood of purchasing GM banana for all the three traits, while higher risk perceptions are associated with less purchase among all the three traits. The socioeconomic characteristics significantly influenced the willingness to purchase the GM banana traits, but rather differently. For example, an increase in education by one unit decreased the likelihood of purchasing GM banana given the three traits (agronomic, nutritional, and taste) and increased the probability of being indifferent, but at different magnitudes. Respondents with higher incomes are associated with less likelihood to purchase GM banana with an agronomic trait but are more likely to purchase GM banana with nutritional and taste traits. Furthermore, being female increases the likelihood of not purchasing GM banana with a taste trait compared to their male counterparts, who would purchase it. The less likelihood to purchase among women respondents was also reported in other studies, such as Govindasamy et al. (2004), Zhong, Marchant, Ding, and Lu (2002) and De Steur et al. (2010). Larger household sizes are associated with less purchase of a GM banana with agronomic trait by 0.011.

Older respondents are less likely to purchase a GM banana with a taste trait but more likely to being indifferent by 0.002. Banana acreage had significant effects on intentions to purchase. Having larger banana farms is associated with more purchase of GM banana with agronomic and nutritional traits by 0.129 and 0.143, respectively, while conversely respondents with smaller banana farms have a higher probability of being indifferent toward purchasing GM banana with agronomic and nutritional traits. For a more causal trait, taste, an increase in banana acreage increases the likelihood of not purchasing a GM banana by 0.017, while a decrease in acreage increases the likelihood of purchasing a taste trait GM banana by 0.013. Banana sellers are likely to purchase neither an agronomic-trait-based GM banana nor a nutritional one, but are more likely to be indifferent on only the agronomic one. The results also show spatial differences, with respondents located in the Central and Eastern Regions more likely not to purchase a taste-trait-based GM banana compared to those from the Southwestern Region, who are more likely to be indifferent to the same trait. Finally, respondents who were solely consumers were more likely to purchase a nutritional-trait-based GM banana, while producers who are also consumers of their own banana were more likely to be indifferent to the nutritional trait. The results suggest that sole consumers are more likely to purchase GM banana that entail direct nutritional benefits, such as enhanced vitamin A and iron. But, additional empirical research is needed to understand in more details why consumers behave differently given the three banana traits.

Consumers' awareness of and trust in organizations

Even though GM crops may have great potential for improving consumers' welfare, lack of confidence in the organizations that govern their development and release could impede public acceptance of biotechnology products in Uganda. To understand the level of awareness of and trust in the organizations involved in the regulation and control of production and the sale and release of foods, beverages, and seed, each respondent was asked one awareness question, and, for the known or heard-of organizations, each respondent was asked to complete the subsequent three trust questions. Only responses that indicated awareness of and trust in an institution ("yes" responses are reported in Table 9 as percentages. Six categories were created: leadership, extension service, research and education, government-owned ministries and parastatals, private sector companies, and nongovernmental organizations (NGOs). The first four categories, though divided, fall under the public sector. For each category, an institution index was calculated. Responses were given scores or weights, following Bett et al. (2010). Average scores were then calculated for each institutional category by taking the mean of the organizations in that category.

Table 9
Respondents' awareness of and trust in organizations responsible for the control or regulation of GM crops and food in Uganda (% of "yes" responses).

Institution	Awareness	Trust/not produce	Trust/not sale	Trust/not release
Leadership				
Local leaders	99	85	65	78
Politicians	99	58	48	58
Public extension service provision				
NAADS	81	81	43	79
Extension workers	78	81	46	75
Research and education				
NARO	52	70	41	73
University scientists	50	67	55	66
UNCST	24	71	57	69
Government ministerial sector				
MAAIF	96	89	65	88
URA	89	25	37	24
NEMA	87	69	39	89
UNBS	71	47	83	38
MOT	70	52	63	47
Private sector				
Cooperatives	83	64	51	58
Food processors	71	50	51	41
UTA	52	55	61	43
UNFFE	48	71	42	72
CONSENT	17	72	75	63
AGT	11	62	48	56
Non-governmental organizations (NGOs)				
NGOs	86	62	50	62

Note: NAADS = National Agricultural Advisory Services; NARO = National Agricultural Research Organization; UNCST = Uganda National Council of Science and Technology; MAAIF = Ministry of Agricultural Animal Industries and Fisheries; URA = Uganda Revenue Authority; NEMA = National Environment Management Authority; UNBS = Uganda National Bureau of Standards; MOT = - Ministry of Trade; UTA = Uganda Traders Association; UNFFE = Uganda National Farmers Federation; CONSENT = Consumer Education Trust; and AGT = Agro-genetic Technologies. Awareness = knowing or hearing about the mentioned institution; trust/not produce = whether a respondent has trust (or not) in the institution to control production; trust/not sale = whether a respondent has trust (or not) in the institution to control sale; trust/not release = whether a respondent has trust (or not) in the institution to control release to the environment of GM crops (food).

Table 10 presents the results of the one-way ANOVA comparisons. The research-and-education sector is the least known and trusted among the public sector entities. Yet the research and education sector is responsible for the development of new technologies in modern biotechnology, such as GM banana. The results suggest that there is a need for the research-and-education sector to become better known and to build trust among the consumers; otherwise, the uptake of its developed technologies may be hindered. The government-owned ministries and the parastatal sector is the most widely known and trusted sector, followed by the extension service and leadership sectors. This implies that, at the farm level, extension services and local leadership may have to play a greater role of disseminating information, while at the consumer level the government-owned ministries and parastatals are likely to be trusted more than any other sector at creating awareness of the new technology. Though the private sector is less known, it may play a major role in creating awareness among those who trust in it. Last, NGOs are known and trusted by a substantial number of consumers.

At the cluster level, although the leadership sector is known by many, the trust placed in it differs only with respect to controlling sales, with the government-trust cluster exhibiting the highest level of respondent confidence compared to the rest. The extension service sector is known mostly by the food and environmental

Table 10
Relationship between awareness of and trust in organizations and attitudinal clusters (by one-way ANOVA).

Institution		Sample	GMS	GT	HS	FES	*F*-test
Leadership	Awareness	0.98	0.94	0.98	0.99	0.99	2.12*
	Trust not produce	0.44	0.44	0.46	0.41	0.47	0.23
	Trust not sale	0.17	−0.16	0.37	0.14	0.13	5.16***
	Trust not release	0.41	0.26	0.42	0.46	0.43	0.53
Extension	Awareness	0.59	0.44	0.17	0.41	0.73	4.72***
	Trust not produce	0.53	0.34	0.55	0.53	0.57	1.61
	Trust not sale	0.01	−0.06	0.09	−0.06	0.03	1.11
	Trust not release	0.48	0.34	0.50	0.47	0.52	1.01
Research and education	Awareness	−0.24	−0.34	−0.44	−0.25	−0.05	3.20**
	Trust not produce	0.30	0.07	0.36	0.32	0.30	2.08
	Trust not sale	0.11	−0.10	0.21	0.08	0.11	2.39*
	Trust not release	0.32	0.15	0.33	0.29	0.38	1.66
Government ministries	Awareness	1.63	1.82	1.32	1.59	1.85	4.39***
	Trust not produce	0.49	0.37	0.64	0.63	0.28	3.09**
	Trust not sale	0.51	0.37	0.54	0.40	0.60	0.93
	Trust not release	0.59	0.41	0.69	0.63	0.51	1.21
Private sector	Awareness	−0.16	−0.18	−0.78	−0.15	0.30	10.55***
	Trust not produce	0.39	0.34	0.56	0.47	0.20	2.63**
	Trust not sale	0.21	0.19	0.38	0.17	0.12	1.29
	Trust not release	0.26	0.26	0.41	0.26	0.15	1.31
NGOs	Awareness	0.36	0.35	0.31	0.38	0.39	1.55
	Trust not produce	0.15	0.12	0.18	0.19	0.11	1.24
	Trust not sale	0.07	−0.01	0.09	0.12	0.04	1.54
	Trust not release	0.15	0.16	0.18	0.16	0.13	0.41

Note: GMS = GM skepticism; GT = government trust; HS = health safety concern; and FES = food and environmental safety concern. Awareness = knowing or hearing about the mentioned institution; trust/not produce = whether a respondent has trust (or not) in the institution to control production; trust/not sale = whether a respondent has trust (or not) in the institution to control sale; and trust/not release = whether a respondent has trust (or not) in the institution to control release to the environment of GM crops (food). Numbers represent mean scores of a given institution in terms of awareness and trust (i.e. if yes = 0.5, don't know = 0 and No. = −0.5).
* Significance at 0.1 level.
** Significance at 0.05 level.
*** Significance at 0.01 level.

safety group, but trust does not differ at cluster level. The research-and-education sector is the least known; it is only trusted by the government-trust group for not allowing the sale of harmful products in shops and restaurants. The government-owned ministries and the parastatal sector is most trusted by the government-trust group for not allowing production of harmful GM products, followed by the health safety group. The private sector is known mostly by the food and environmental safety cluster, and it is the least known in the government-trust group. The two groups trust it not to allow production of harmful products in the country. NGOs were similarly known and trusted across the four clusters.

With respect to consumer type as presented in Table 11, the leadership sector is known by many. The trust put in leaders differs with respect to controlling sales, with adopters displaying a higher level of confidence compared to the sole consumers. Awareness of and trust in the extension service sector among adopters and sole consumers differs significantly. The sector is better known among adopters; they trust the sector more in not allowing producing, selling, or releasing harmful products compared to sole consumers. Although awareness of the research-and-education sector does not differ, adopters show a significantly higher trust for controlling sales than sole consumers. Sole consumers were better aware of the government-owned ministries and the parastatal sector compared to adopters, but trust in the sector does not differ significantly. The private sector and NGOs were not well known and showed no difference in trust between adopters and sole consumers.

Table 11
Comparisons between awareness of and trust in organizations and consumer types.

Institution		Adopters	Sole consumer	*t*-Test
Leadership	Awareness	0.99	0.96	2.31**
	Trust not produce	0.46	0.37	1.14
	Trust not sale	0.24	−0.11	3.85***
	Trust not release	0.43	0.31	1.45
Extension	Awareness	0.64	0.39	3.19***
	Trust not produce	0.57	0.40	2.49**
	Trust not sale	0.06	−0.16	2.51**
	Trust not release	0.52	0.34	2.54**
Research and education	Awareness	−0.23	−0.25	0.10
	Trust not produce	0.32	0.24	1.08
	Trust not sale	0.15	−0.04	2.43**
	Trust not release	0.33	0.28	0.79
Government ministries	Awareness	1.57	1.89	−2.19**
	Trust not produce	0.49	0.48	0.07
	Trust not sale	0.51	0.51	0.01
	Trust not release	0.60	0.53	0.55
Private sector	Awareness	−0.16	−0.16	−0.00
	Trust not produce	0.40	0.35	0.38
	Trust not sale	0.24	0.08	1.18
	Trust not release	0.30	0.11	1.43
NGOs	Awareness	0.37	0.32	1.13
	Trust not produce	0.16	0.14	0.39
	Trust not sale	0.08	0.04	0.74
	Trust not release	0.17	0.10	1.31

Note: GMS = GM skepticism; GT = government trust; HS = health safety concern; and FES = food and environmental safety concern. Awareness = knowing or hearing about the mentioned institution; trust/not produce = whether a respondent has trust (or not) in the institution to control production; trust/not sale = whether a respondent has trust (or not) in the institution to control sale; and trust/not release = whether a respondent has trust (or not) in the institution to control release to the environment of GM crops (food). Numbers represent mean scores of a given institution in terms of awareness and trust (i.e. if yes = 0.5, don't know = 0 and No. = −0.5).
** Significance at 0.05 level.
*** Significance at 0.01 level.

Conclusions

Focusing on the consumers' opinions regarding the introduction of GM banana in Uganda, the following conclusions can be

made. Price and quality are the most important product factors considered when shopping banana. Consumers are in general willing to purchase GM banana at the same price as the non-GM banana, given the potential quality benefits (78–92 percent) and based on factor analysis results, Ugandan consumers have three attitudinal and perception factors: benefit, health, and food–environmental factors. The benefit factor refers to the potential benefits of GM technology, while the health and food–environmental factors are risk concerns of the technology in relation to health safety and food and environmental safety, respectively. Our results concur with those of other studies in Africa: consumers were willing to purchase GM food at the same price as the non-GM food but were concerned about safety issues (Bett et al., 2010; Kimenju & De Groote, 2008; Kushwaha et al., 2008).

Cluster analysis results suggest that Ugandan public opinion with regard to GM banana may be divided into four consumer segments, or clusters: (1) consumers who are more concerned about the unknown risks than the potential benefits of GM products, (2) consumers who are in favor of GM banana (food) and do not perceive any potential risks of the technology because they have trust and confidence in government's ability to protect consumer interests, (3) those who have positive attitude toward GM products but who perceive health risks associated with technology, and (4) consumers who have a positive perception of the benefits derived from GM products while also perceiving that GM products may have negative effects on food and the environment. Such consumer segmentation may be helpful when designing marketing strategies. A multinomial regression shows that socioeconomic characteristics (such as age, banana acreage, consumer type, region, and location) varied significantly across segments, which can be useful to explain segment membership.

Likewise, multinomial regression results show that consumer characteristics (age, education, income, and so forth) and perception factors influence consumers' willingness to purchase GM banana given the three traits (agronomic, nutritional, and taste). In particular, unlike Kikulwe, Birol, Wesseler, and Falck-Zepeda (2011), who found that urban consumers (who are mostly sole consumers) are only willing to accept GM bananas at a discounted price for both the GM attribute and the benefits to farmers attribute, our results confirm studies by Loureiro and Bugbee (2005), Lusk et al. (2005), and González et al. (2009) showing that sole consumers would appreciate a GM banana with nutritional enhancement traits (direct benefits to consumers) and would be willing to purchase it at the same price as a non-GM banana.

The public sector as a whole (particularly government-owned ministries and parastatals) is the most widely known and trusted among consumers, compared to the private sector. However, there was a very low awareness of and trust in the scientific community (the research-and-education sector) within the public sector, which is important because the scientific community is responsible for the development (and dissemination) of GM products. At the cluster and consumer type levels, known and trusted organizations varied significantly. Therefore, understanding institutional awareness as well as public trust and confidence in such organizations would help to develop dissemination and marketing strategies.

Another important issue is the segmentation of consumer as adopters (who are both producers and consumers) and sole consumers. Results show adopters consider the environmental factor more, while for sole consumers quality (taste and nutrition) is more important. With respect to perception, sole consumers were found to exhibit higher health concerns regarding the technology than the adopters. Choice of GM banana traits also differed among the two groups, with sole consumers preferring nutritional-based traits. At cluster level, adopters were more neutral and placed more trust in the government at handling the GM technology, while sole consumers were more skeptical. In terms of awareness and trust, results show that both adopters and consumers know and trust government organizations, with adopters knowing and trusting them more than sole consumers.

Overall the results of the study indicate that, although consumers exhibited concern about the unknown negative effects of GM technology, there is a considerably high positive potential for purchasing GM banana (crops) given the expected quality benefits. Findings also show that different consumer segments know and trust the public sector, especially government-owned ministries and parastatals, leadership, and extension service. However, the needs and characteristics of the consumer segments who expressed more concerns about risks than benefits of GM crops, especially the GM skeptical group, should be considered when designing strategies of introducing GM banana (or other GM products). Similarly, when risk assessment has been successful and GM banana has been found safe for commercialization, the findings would be essential to policy makers when designing risk communication strategies that target different consumer segments to ensure proper discussion and address potential concerns about GM technology.

The linking of both consumers and adopters in one analysis contributes to our understanding of public opinion toward GM banana and other crops. In particular, findings in this study have shown that if a technology has direct tangible benefits that could improve the well-being of a consumer, that technology would find its way easily to the end users. As breeders develop agronomic traits to improve the livelihoods of farmers, they should consider the development of other traits that could be beneficial to and therefore preferred by different chain actors.

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Appendix A. Product factors and consumer socioeconomic characteristics

Product factors	Characteristics			
	Sex	Age	Education	Income
Price				
Not agree	0.37 (0.49)	39.51 (14.88)	6.87 (4.73)	201,961.6 (403,343.2)
Uncertain	0.37 (0.49)	39.31 (15.29)	8.27 (4.88)	334,737.0 (570,657.5)
Agree	0.45 (0.50)	41.22 (15.44)	7.11 (4.36)	172,738.6 (291,403.7)
F-test	1.12	1.60	0.83	1.98***
Taste				
Not agree	0.37 (0.50)	45.75 (18.49)	7.87 (4.69)	211,395.8 (327,772.7)
Uncertain	0.45 (0.50)	39.68 (15.47)	6.35 (5.01)	182,088.7 (255,020.3)
Agree	0.43 (0.50)	40.68 (15.19)	7.26 (4.42)	195,086.0 (359,569.0)
F-test	1.49**	0.07	0.86	1.00
Nutrition				
Not agree	0.41 (0.50)	40.23 (14.49)	6.28 (4.27)	190,566.1 (389,464.6)
Uncertain	0.45 (0.50)	41.12 (15.14)	7.80 (4.40)	186,387.0 (316,200.9)
Agree	0.43 (0.49)	40.83 (15.68)	7.26 (4.52)	198,754.0 (353,122.9)
F-test	0.69	0.00	0.92	1.06
Health				
Not agree	0.47 (0.50)	39.43 (15.44)	7.47 (4.71)	171,957.1 (303,852.8)
Uncertain	0.38 (0.49)	44.04 (16.06)	7.30 (4.46)	178,541.1 (332,791.1)
Agree	0.43 (0.49)	40.39 (14.96)	7.06 (4.36)	211,644.2 (378,765.6)
F-test	0.95	0.51	0.70	0.95
Environment				
Not agree	0.47 (0.50)	40.13 (15.64)	7.20 (4.84)	168,884.9 (300,201.8)
Uncertain	0.41 (0.49)	41.36 (15.66)	7.46 (4.38)	210,843.0 (350,808.5)
Agree	0.41 (0.49)	41.10 (14.86)	7.05 (4.13)	210,985.8 (399,528.2)
F-test	1.11	1.17	1.07	0.90

Note: Standard deviations are in parentheses.
** Significance at 0.05 level.
*** Significance at 0.01 level.

Appendix B. Product factors and consumer types (sole consumers vs. adopters)

Product factors	Consumer type		
	Adopters	Sole consumers	Chi^2-test
Price			
Not agree	12.43	10.84	
Uncertain	9.76	18.07	
Agree	77.81	71.08	4.57
Taste			
Not agree	4.44	1.20	
Uncertain	8.58	2.41	
Agree	86.98	96.39	5.94*
Nutrition			
Not agree	18.34	9.64	
Uncertain	19.82	27.71	
Agree	61.83	62.65	4.98*
Health			
Not agree	26.33	31.33	
Uncertain	17.75	20.48	
Agree	55.92	48.19	1.61
Environment			
Not agree	36.69	45.78	
Uncertain	24.56	30.12	
Agree	38.76	24.10	6.23**

* Significance at 0.1 level.
** Significance at 0.05 level.

Appendix C. A comparison of perception factors and consumer types

Perceptions	Consumer types		*t*-Test
	Adopters	Sole consumers	
	Mean factor scores (standard deviations)		
Benefit	0.06 (0.81)	−0.11 (1.08)	1.58
Food and environment	−0.02 (0.88)	0.01 (0.75)	−0.22
Health	−0.07 (0.86)	0.21 (0.75)	−2.72***

Note: Standard deviations are in parentheses.
*** Significance at 0.01 level.