AgBioForum, 12(3&4): 382-393. ©2009 AgBioForum.

Stakeholder Positions Toward GM Food: the Case of Vitamin A Biofortified Cassava in Brazil

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This article examines the factors that affect stakeholders' positions toward genetically modified (GM) crops in Brazil, both in general and in the case of GM cassava in particular. Perceptions about the benefits of second-generation GM crops that have direct benefits for consumer are analyzed, and the tradeoffs that stakeholders make between the advantages of GM crops in terms of food quality and their potential risks in other areas as the environment are assessed. Using the Multiple Correspondence Analysis and cluster approaches, it was revealed that most of the stakeholders have positive attitudes toward GM crops. A high percentage agrees with the introduction of a GM cassava; however, a significant number of stakeholders are against this introduction because Brazil has other nutritional sources to combat Vitamin A deficiency. In addition, the country is a center of origin and diversity for cassava, which increases potential environmental risk associated with GMO release.

Key words: Brazil, cassava, center of origin, GM food, Multiple Correspondence Analyses, stakeholder positions.

Introduction

Governments and civil society recognize that modern biotechnology has enormous potential, for human health as well as for environmental and economic development. The first generation of genetically modified organisms (GMOs) in agriculture allows farmers to increase yields and reduce the use of agricultural chemicals. The second-generation of genetically modified (GM) foods is probably most interesting for consumers because these are products with enhanced-quality attributes or nutritional benefits (Onyango & Nayga, 2004).

The first generation of GMOs experienced fast adoption rates in the United States and some developing countries such as Argentina (Qaim & Zilberman, 2003). However, GM food products have faced mixed regulatory and public acceptance because of the multiple concerns over the human and environmental safety of these technologies. The vast majority of studies on consumer attitudes and the acceptance of GM foods have been conducted in developed countries, where most of the controversy over GM foods originated.

Because they continue struggling to achieve food security, developing countries may stand to benefit most from agricultural biotechnology. However, little is known about how the stakeholders in developing countries would respond to the second generation of GM food (Dawe & Unnevehr, 2007; Gonzalez, Johnson, & Qaim, 2009; Juma, Paarlberg, Pray, & Unnevehr, 2007). What Paarlberg (2003) observed is that developing countries have become a battleground between proponents and opponents of GMOs with governments of developed countries and non-governmental organizations (NGOs) trying to influence the developing countries' position toward biotechnology. Aerni (2005) and Aerni and Bernauer (2006) found support for the Paarlberg argument when they concluded that in developing countries, local NGOs have adopted a political agenda against or in favor of agricultural biotechnology depending on their foreign donors, normally international NGOs or organizations. To avoid ineffective political polarization, Paarlberg suggests increasing the participation of local academia in the public debate since these institutions have a potential domestic leadership role, especially regarding agricultural biotechnology. People still trust academia more than other stakeholders, therefore they can use this political resource to focus the biotechnology debate on domestic problems and curb the foreign interference. These studies suggest that much work needs to be done, starting with understanding the true internal position of developing countries, which is decisive for future of these technologies (Juma et al., 2007).

Following the model of Aerni and Bernauer (2006), this article examines which factors affect stakeholder positions toward GM food crops in Brazil, paying special attention to the case of a new GM cassava biofortified with provitamin A. Perceptions about the benefits of the so-called second-generation GM crops that have direct benefits for consumer are analyzed, and the tradeoffs that stakeholders make between the advan-

tages of GM crops in terms of food quality and their potential risks in other areas such as the environment are assessed. The environmental question is especially relevant in this case because Brazil is the center of origin and genetic diversity for cassava (Nassar, 1978).

The article begins with a brief account of the introduction of GMOs in Brazil and the current political situation with respect to this topic. The second section explains the framework and methodology used. Then, we identify the stakeholders in Brazilian biotechnology and characterize their positions towards GM food and the possible introduction of GM cassava biofortified with more provitamin A. Additionally in this section, we analyze the factors that affect stakeholder positions. The last section summarizes and concludes with recommendations for policy.

GMOs in Brazil

GMO policy in Brazil has been ambiguous from its beginnings. Since 1995, this country has attempted to develop biosafety legislation and to establish a structure for monitoring the introduction of GMOs. The Law 8974 and Decree 1752/1995 created the National Biosafety Committee (CTNBio), a governmental agency responsible for developing guidelines on GMO use in Brazil. The national policy permitted research on GMOs and allowed commercial products that contained GM material but prohibited commercial production of GM crops (Oda & Soares, 2000). In 1998, Monsanto requested and received CTNBio permission to market the Roundup Ready® soybean. After that, an injunction against Monsanto and CTNBio was filed by Greenpeace and the Brazilian consumer's institute (IDEC) on the basis that this crop could be harmful for the environment. In 2000, the court ruled to prohibit cultivation and commercialization of the GM soybean.

During October/November 1999, a report suggested that 2 million hectares were planted with illegal seed bought in Argentina (Sampaio, 1999). For this reason, although there were moratorium laws prohibiting the commercial use of GMOs until 2005, the government currently offers amnesty to soy farmers who had illegally planted GM soy during the 2003-2005 ban (Neto, 2003).

In 2005, Brazil released the controversial Biossegurança Law. This law permits production, transportation, import, export, storage, transformation, research, and trade of GMOs. There were also some important changes regarding the CTNBio. Under the old legislation, this institution was a part of the Presidency; currently, it belongs to the Ministry of Science and Technology. Organizations opposed to GMOs interpreted this change as a loss of independence. In addition, the scope of CTNBio was extended beyond release of GMOs into the environment to also include topics such as health and social issues related to GMOs.

Despite the lack of a clear policy during the period 1999-2005, the industrial sector and the national research establishment in Brazil were interested in developing biotechnology products. EMBRAPA (the Brazilian agricultural research center) worked either alone or together with national and multinational companies to develop a wide range of GM crops, including corn, soybean, cotton, eucalyptus, sugarcane, tobacco, potatoes, sweet corn, and papaya (Portugal, Sampaio, Contini, & Avila, 2001). Because of the moratorium, however, some of that research was lost. Currently, there are few commercial, foreign, or domestic GM crops in Brazil, mainly soy, cotton, and corn.

Framework and Methodology

The development of GM crops has been accompanied by studies about public and consumer acceptance, using a range of different methodological approaches. Bredahl, Grunert, and Frewer (1998) reviewed three models that seek to explain consumer attitudes, buying behavior, and attitude change regarding genetically engineered food products. The first model, built on Fishbein's multi-attribute attitude model, suggests that attitudes towards genetic engineering are determined by beliefs, either about production processes or perceived quality of the final products. Demographic characteristics and other factors are assumed to influence attitudes only indirectly.

Many studies based on this model have been conducted with different GM food innovations in different countries and consumer contexts. Some studies conclude that public trust is a decisive factor in determining consumer attitudes (Barling et al., 1999; House, Morrow, Lusk, & Moore, 2001), while other research suggests that consumer attitudes are the results of risk-benefit perceptions (Barling et al., 1999; Boecker, Nocella, Bertazzoli, & Lucchi, 2004; Bredahl et al., 1998; House et al., 2001). Socio-economic characteristics have also been shown to have a significant influence in people's perceptions (Hoosain, Onyango, Adelaja, Schilling, & Hallman, 2003; Li, Curtis, McCluskey, & Wahl, 2002). In the case of GM foods, socio-economic variables might be more important in a developing-country context where expenditure on food constitutes a

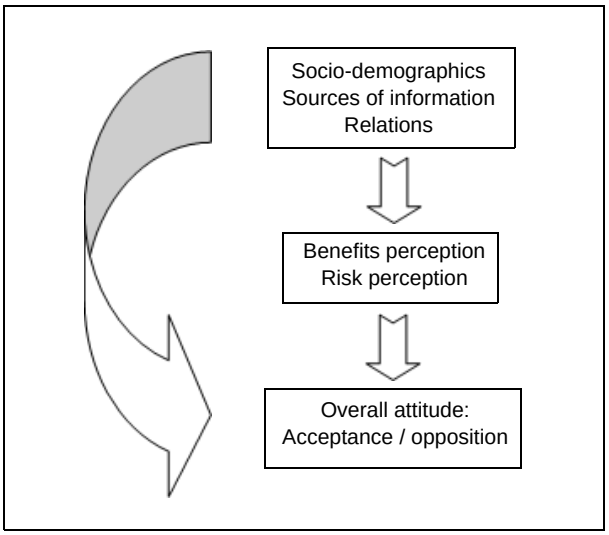

Figure 1. Benefits/risk perception on GM food.

larger share of household budget than in developed countries.

Most of these studies were conducted using consumer-based surveys; however, according to Aerni and Bernauer (2006), another way to assess the public perception about biotechnology is to analyze the actors that influence public opinion through stakeholder-based surveys. This approach focuses on those actors who claim to represent some public or private interests (Laumann & Knoke, 1987). For Aerni (2005), the individual perceptions about agricultural biotechnology are ultimately influenced by the information distributed in the mass media from key stakeholders in industry, government, public interest groups, and academia. Further, the selection of the sources of information is influenced by characteristics like individuals' social status, personal worldview, and interests. A further advantage of this stakeholder-based approach avoids a possible bias in results due to the low awareness of GM technology by direct consumers, a very common situation in developing countries that limits the extent to which perceptions can be rigorously analyzed. Also, it allows deepening in some topics because we suppose that these types of actors have an informed opinion. Studies about consumer perception typically show that responses are based on the information received from their selected sources, suggesting that the source of information might affect consumer choices and willingness to pay (Hu, Chen, & Yoshida, 2006).

In this study, we applied the stakeholder-based survey approach using risk and benefits perceptions in order to analyze the position of stakeholders towards GM crops. To explain the overall attitudes (acceptance or opposition) toward GM food, we used socio-demographic variables, proxies for beliefs, access to information, and relationships that stakeholders maintain with different types of actors. The underlying conceptual model is presented in the Figure 1.

Table 1. Inventory and sample.

Organizations	N	Sample
1. Non-governmental organizations (environmental, industrial, consumer organizations)	49	20
2. Public authorities: Government and legislators **- Ministries: Agriculture, Science and Technology, Health, Environmental, and Agricultural Development** **- State institutes of agriculture** **- Financial public institutes** **- Legislators**	32	18
3. Local industries and multinationals	59	24
4. Universities	36	19
5. National research centers (public and private research centers)	24	17
Total	200	98

The Data

An inventory of 200 public and private organizations that actively participate in the GM debate in Brazil was developed based on input from key informants, and a database of the CTNBio (Table 1) and key individuals in each organization were identified. A stratified sample (by type of stakeholders) of 98 organizations was randomly selected and a structured questionnaire was applied via interviews (e-mail, telephone, and in person) from July through August 2008. Individuals from government agencies (Agriculture, Agriculture Development, Environment, Health, and Science and Technology), consumer and other civil society organizations, industry (local and multinational), agriculture research institutes (public and private), NGOs, and members of the legislature participated in the study. It is important to note that responses reflected the personal perceptions of the respondents rather than the official positions of their organizations.

The purpose of the interview was to obtain information about the positions of the stakeholder towards GMOs in general and the possible introduction of a GM cassava enhanced with provitamin A in particular. This cultivar is being developed to combat Vitamin A deficiency (VAD) as a part of a biofortification strategy; biofortification involves increasing the micronutrient

Table 2. Stakeholder perceptions about GM crops.

Perceptions (%)	Totally disagree	Disagree	Agree	Totally agree	Indifferent	Mean value [a]
The biosafety regulation is clear and avoids the wrong use of GM crops	12.2%	22.5%	53.1%	10.2%	2.0%	2.63
Brazilian institutions do not have the capacity to monitor GM crops	31.6%	8.2%	18.4%	38.8%	3.1%	2.31
Production of GM crops implies ethical problems	16.3%	40.8%	28.6%	10.2%	4.1%	2.34
GM crops are safe for the environment	5.1%	18.4%	48.0%	22.5%	6.1%	2.93
Consuming GM foods could be risky for human health	14.3%	50.0%	23.5%	6.1%	6.1%	2.38
GM crops are useful for solving problems that could not be solved by other approaches	6.1%	12.2%	55.1%	22.5%	4.1%	2.98
GM food crops could help to ensure the food supply in Brazil	11.2%	18.4%	50.0%	19.4%	1.0%	2.78
To become 'GM-free' is a good strategy to increase Brazil's competitiveness	25.51%	42.86%	24.5%	3.06%	4.08%	2.05
GM crops could reduce some production costs so that revenues could increase	3.1%	23.5%	61.2%	10.2%	2.0%	2.80
GMOs developed by national research centers have more acceptance that those developed by multinationals	40.8%	6.1%	35.7%	8.2%	8.2%	2.51

Note. Responses were valuated from 1 (totally disagree) and 4 (totally agree).
[a] The 'indifferent' category was excluded.

content of staple food crops through plant breeding techniques (HarvestPlus website). Stakeholder perceptions were assessed by asking respondents whether they agreed or disagreed with a series of statements about GMOs and GM cassava (see Appendix). A four-point scale ranging from 1 (totally disagree) to 4 (totally agree) was used. A fifth option, "indifferent," was allowed. Respondents were also asked about their trust in institutions that provide information about GMOs, their opinions about agricultural development in Brazil, and their relationships with other actors in science and technology, agriculture, and industry.

Results

Based on our sample, 69% of stakeholders in Brazilian biotechnology are male. Approximately 50% are agronomic engineers, while 36% have backgrounds in biology or chemistry and 14% in social science. Fifty-four percent have PhDs, 18% have Masters degrees, and 4% only have high-school degrees. Finally, 93% and 43% said that they have no political or religious affiliations, respectively.

Stakeholder Perception Towards GM Food

Respondents were presented with 10 statements about general perceptions of GM foods (Table 2)—both risk (negative) and benefit (positive) statements to avoid a bias. The first two statements were related to the clarity of biosafety law in Brazil and the capacity of the authorities to evaluate and monitor the GM food crops. Most respondents agreed that the biosafety legislation is clear and avoids the wrongful use of GM crops in the country (63%).[1]

Despite the high levels of support for existing biosafety legislation, 57% of stakeholders had negative attitudes toward the nation's capacity to evaluate and monitor GM crops. They clarify that Brazil has qualified people to work in this area, but still does not have the required infrastructure to undertake the necessary activities.

Regarding perceptions about environmental damage or risk to human health, respondents are not very concerned about these topics. Only 24% and 30%, respectively, think that even when the biosafety guidelines are

1. *To facilitate the reading, we clubbed the two agree and two disagree responses of the fourth-point scale.*

Table 3. Stakeholder perceptions about an introduction of GM cassava with provitamin A.

Perceptions (%)	Totally disagree	Disagree	Agree	Totally agree	Indifferent	Mean value[a]
The second generation of GM crops will find more public acceptance because of the nutritional qualities	3.1%	26.5%	9.2%	58.2%	3.1%	3.26
A country that is a crop diversity center (e.g., Brazil: cassava) should not use GM versions of this crop	12.2%	46.9%	11.2%	21.4%	8.2%	2.46
Because of the failure to approve GM food crops, consumers could lose many nutritional benefits	12.2%	22.4%	9.2%	50.0%	6.1%	3.03
It is better to continue using the current strategies to combat VAD than to introduce a complementary tool such as GM cassava	12.2%	45.9%	27.6%	12.2%	2.0%	2.75
GM cassava with more provitamin A could have a potential ecological risk	12.2%	44.9%	7.1%	22.4%	13.3%	2.46
GM cassava with more provitamin A is against the Brazilian culture and traditional knowledge	20.4%	44.9%	7.1%	21.4%	6.1%	2.32
The introduction of a new cassava with more provitamin A is possible in Brazil	5.1%	19.4%	10.2%	59.2%	6.1%	3.32

Note. Responses were valuated from 1 (totally disagree) and 4 (totally agree).
[a] The 'indifferent' category was excluded.

applied, GM crops are not safe for the environment or human consumption. For them, there are two main concerns. The first relates to the appropriateness of GM crops developed and tested outside of Brazil for Brazilian conditions. Second, there are no ex-post studies about long-term environmental and health-risk effects of GM crops. People highlighted that it is important in each GM release event to conduct ex-ante evaluation studies to be sure that the GM crop is safe not only for the environment but also for human health.

According to the results, a high percentage of respondents think that GMO technologies could generate some benefits in terms of agricultural competitiveness. Approximately 70% believe that GMOs could increase food production and potentially enhance food security. The same percentage of stakeholders perceives that these products could reduce production costs and increase producer profits. More than 75% agreed that GM crops are useful to solve problems that cannot be solved by traditional breeding approaches. Similar results have been found in other developing countries, such as Colombia, China, and Argentina. Because of nutritional and competitiveness problems, GM food could be a good solution for the challenges facing developing countries (Curtis, McCluskey, & Wahl, 2003).

In response to a statement about whether GM food developed by national research centers/enterprises would be more acceptable to the public than those developed by multinationals, opinions were mixed. Forty-four percent consider that the type of institution that developed the GM crop important for consumer acceptance, while 46% think that is not important. One possible reason is that Brazil, like other developing countries, has a low level of consumer knowledge and consumer awareness on this topic (Guivant, 2006).

The statement with the highest level of agreement was about the usefulness of GM crops to solve problems unsolved by other techniques (average rating=2.98). The statement with the lowest acceptance level related to Brazil becoming a GM-free country to increase its competitiveness (average rating=2.05). These results suggest a high level of pragmatism among biotechnology stakeholders in Brazil.

Stakeholder Perception Towards Introduction of a Cassava with More Provitamin A

The second generation of GMOs, usually GM foods, was developed to offer direct benefits to consumers (e.g., via nutritional quality) and to the environment (Hout, 2002). Results from studies in developed countries about consumer attitudes toward GM food seem to indicate that attitudes can change; opposition to GM foods may be reduced when direct benefits are associated with them (House et al., 2001). In this study, we

Table 4. Characterization of group perceptions (clusters).

Perceptions: Percent in agreement	Clusters		
	Group 1 (n=65)	Group 2 (n=19)	Group 3 (n=14)
The biosafety regulation is clear and avoids the wrong use of GMO	84.62	36.84	0.00
Brazilian institutions do not have the capacity to monitor GM crops	29.23	47.37	78.57
Production of GM crops implies ethical problems	15.38	78.95	92.86
GM crops are safe for the environment	90.77	52.63	0.00
Consuming GM foods could be risky for human health	9.23	52.63	92.86
GM crops are useful to solve problems that could not be solved by other approaches	92.31	63.16	28.57
GM food crops could help ensure the food supply in Brazil	84.62	57.89	14.29
To become 'GM-free' is a good strategy to increase Brazil's competitiveness	10.77	31.58	100
GM crops could reduce some production costs so that revenues could increase	90.77	47.37	14.29
GMOs developed by national research centers have more acceptance than those developed by multinationals	45.31	52.63	28.57
The second generation of GM crops will find more public acceptance because of the nutritional qualities	86.15	42.11	14.29
A country that is a crop diversity center (e.g., Brazil: cassava) should not use GM versions of this crop	12.31	57.89	92.86
Because of the failure to approve GM food crops, consumers could lose many nutritional benefits	75.38	26.32	28.57
It is better to continue using the current strategies to combat VAD than to introduce a complementary tool such as GM cassava	21.54	73.68	78.57
GM cassava could have a potential ecological risk	10.77	42.11	100
GM cassava with more provitamin A is against the Brazilian culture and traditional knowledge	10.77	42.11	92.86
The introduction of a GM cassava with more provitamin A is possible in Brazil	83.08	36.84	50.00
Trust in international NGOs	10.45	28.57	78.57
Trust in local NGOs	4.48	28.57	57.14
Trust in universities	80.60	71.43	28.57
Trust in mass media	7.58	7.14	0.00
Trust in government	34.33	21.43	0.00
Trust in local industries	28.36	0.00	0.00
Trust in multinational industries	38.81	7.14	0.00
Trust in international organizations	95.52	71.43	28.57
Trust in national research centers	89.55	71.43	14.29
Trust in international research centers	94.03	57.14	21.43

confirm those results. Two thirds of respondents agreed that second-generation GM crops could increase consumer acceptance as compared to first-generation GMOs, whose benefits were mainly captured by producers (Table 3). Stakeholders also perceived that nutritional benefits might be foregone if GM cassava was forbidden (60%).

In the specific case of a GM cassava with more provitamin A, the patterns of perceptions are the same. In Brazil, cassava has a high cultural, economic, nutritional, and social value, and the country is also the center of origin and genetic diversity of the crop. Most of the stakeholders, however, were not concerned about the introduction of this GM crop. They agreed with complementing current strategies to combat VAD, such as supplementation or strengthening the program of nutritional education and dietary diversification with the introduction of GM cassava (59%). The Biosafety Law does not prohibit the introduction of a GM crop into its center of diversity, and this was reflected in the high percentage of responses (70%) that believe the introduction could be possible.

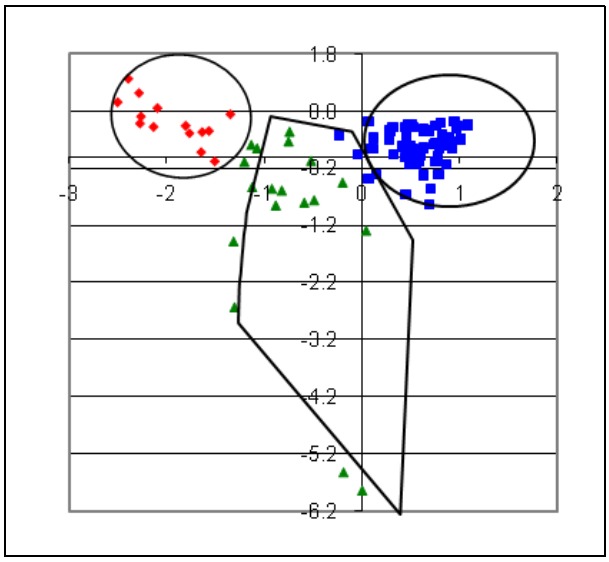

Figure 2. Cluster analysis (n=98).

Characterizing Stakeholder Groups

We used the multiple correspondence analyses (MCA) to characterize and understand the stakeholder positions toward GM crops based on the perceptions described above. These approaches are very useful for exploring and categorizing datasets without imposing any predetermined relationships between the variables. MCA reduces the number of variables and detects the relationships among levels of the variables (Lebart, Morineau, & Warwick, 1984). Twenty-two descriptive variables were selected from data gathered in the questionnaire.[2] The variables with greater discriminatory power are (a) GM crops are safe for the environment if biosafety guidelines are considered, (b) a country that is a crop origin and diversity center (example Brazil: cassava) should not breed a GM version of this crop (GM cassava), (c) consuming GM food could be risky for human health, (d) the new GM cassava with more provitamin A could have a potential ecological risk, (e) the GM cassava with more provitamin-A content is against the Brazilian culture and traditional knowledge, and (f) level of trust in international organizations (e.g., FAO). Although the MCA simplifies the discriminatory power of all the variables into two dimensions, some of the variables have more discriminatory power in one dimension than in the other. Such a distinction serves to describe the dimensions. For instance, the variable *level of trust in international organizations* explains the dispersion along dimension 1.[3]

A subsequent cluster analysis was conducted using the two dimensions that conserved around of 63% of explained variance; each dimension was weighted according to the quantity of variance explained, 43 % and 20%, respectively. The first step consisted of identifying the number of clusters or groups using a dendrogram. After a hierarchical classification procedure using the Ward method, three groups of stakeholder positions were identified (Table 4; Figure 2).

Group 1 (located in the right section of Figure 2) is the largest group, consisting of 66 % of respondents. The stakeholders in this group generally have a positive attitude toward GM food. Approximately 85% agree that there are potential benefits of GM food, and 91% are not worried about the environmental and health risks. Eighty-three percent of this group agrees with the introduction of a GM cassava with more provitamin A in Brazil, which is very similar to the percentage of acceptance of GM food in general in this group. Stakeholders in this group are less concerned about risks of introducing a GM cassava in its origin center (Brazil), and they do not believe that current efforts to combat VAD are sufficient.

Group 2 (in the middle section of Figure 2) consists of 19 respondents with a moderate, pragmatic position toward GM crops. Most of them agree with the use of GM crops in general, however they do not agree with the introduction of a GM cassava with more provitamin A. Only 37% of the members of this group support the idea. The main reason is because Brazil has other tools available to combat VAD; therefore, it is not necessary to use genetic modification. Having said that, the members of this group think that in other places with fewer alternatives for fighting VAD (such as Africa), GM cassava could be useful. This group has two individuals (lower part of the graph) with behavior slightly different. They are characterized by not taking a position toward the statements. Most of their answers were 'indifferent.'

Group 3 (the upper-left in Figure 2) is the smallest with 14 respondents. This group's perceptions of GM crops are mostly negative. They find no potential benefits either for GM crops in general or for the specific

2. *Initially we began the study with 40 variables. However, according to MCA results, only 22 variables had discriminatory power.*

3. *The discriminatory power is related to the heterogeneity of the answers, which indicates that variables that are excluded have very similar answers (homogeneous). Eigenvalues are the new variables obtained with the MCA; they are useful to interpret the dimension results.*

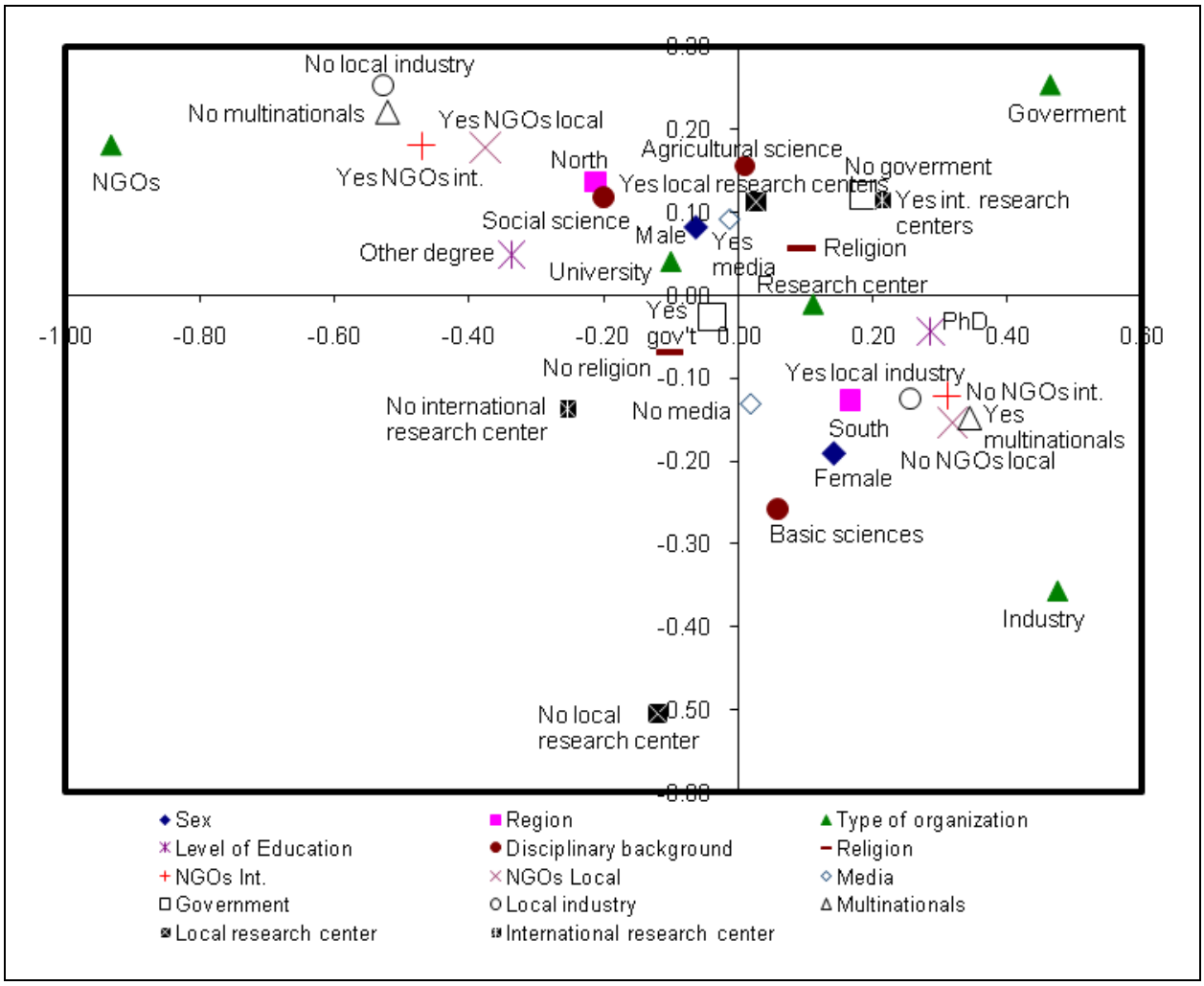

Figure 3. MCA analyses.

GM cassava. This group has links to international and national NGOs. They have little trust in GM-related information coming from universities or international and national research centers and none at all when the information is from mass media, government agencies, or local and multinational industries.

The MCA results also reveal the relative differences and similarities among the groups in terms of the characteristics of their members (Figure 3). Points located farthest from the center indicate that the characteristic is unique to the type of group. This does not imply that the groups are only defined by these characteristics but rather that the attributes are not present in the other groups. In contrast, points located near to one of the 0-0 axes signify that the characteristic pertains to more than one group. The link between the cluster analysis and the MCA comes in superimposing the centers of the graphics.

The main attributes of Group 1 are the high representation of stakeholders related to industry and government agencies, most of which are located in the south of Brazil where agriculture is more industrialized and most likely to benefit from new technologies. All the stakeholders in this group believe that science is extremely necessary to resolve agricultural problems.

Group 2 is associated with the academic sector. This group has the highest level of education, and most of them studied a career associated with biology and chemistry, compared to Group 1 (agricultural science) or Group 3 (agriculture and social sciences). Group 3 does not have representation in industry or government agencies; most of the stakeholders are NGOs, with a few from universities and research centers. The organiza-

Table 5. Logit models.

Variables	GM-free is NOT a good strategy of competitiveness [a]		GM cassava could be used in its diversity center [b]	
	Coef.	Std. Err.	Coef.	Std. Err.
Age of respondent (years)	0.06*	0.04	0.02	0.02
PhD, dummy (yes=1)	2.09***	0.77	0.97*	0.55
Religion, dummy (yes=1)	-0.67	0.68	0.87*	0.52
Sustainable agriculture, dummy (yes=1)	-2.27***	0.75	-0.70	0.60
Relations with NGOs, dummy (yes=1)	-1.33*	0.78	-0.73	0.57
Relations with industry sector, dummy (yes=1)	1.51*	0.81	1.51**	0.63
Relations with research sector, dummy (yes=1)	0.88	1.07	-0.69	0.79
Relations with government sector, dummy (yes=1)	-1.48	1.15	-1.99**	0.92
Intercept	-0.87	1.75	-0.58	1.33
Log likelihood	-32.91		-38.49	
Chi-squared	50.94***		27.08***	

[a] n=95

*[b] n=97; *,**,*** Statistically significant at the 0.10, 0.05 and 0.01 level, respectively.*

tions of this group are mainly located in the north of Brazil, and their level of education is the lowest among the three groups.

It has been hypothesized that the relations of stakeholders determine to some degree their perceptions (Paarlberg, 2003). In the last part of the survey, respondents were asked if they have relationships with specific types of organizations. If they said yes, the next questions asked about the type of relation (commercial, financial, or cooperation) and strength of relation (less strong, strong, and very strong). Most of the stakeholders have many relationships, and all groups are related in some way with government agencies, mass media, and research centers. Groups 1 and 2 both mainly have relationships with local and multinational industries and Group 3 with local and international NGOs. These results are consistent with the studies about public opinions of GM crops in developed countries (Curtis et al., 2003). The debate between NGOs and industry is being moved to developing countries. In the case of Brazil, this situation is reflected at high political levels, but not yet at consumer levels as some studies showed (Guivant, 2006).

Factors that Influence the Stakeholder Positions

To assess the factors (variables) that influence perception of the stakeholders, we estimated a logit model to explain responses to the two statements with the greatest discriminatory power, which also characterized very well the topics of this study. The first one was: "to become a 'GM-free' country is not a good strategy to increase Brazil's competitiveness in the global market; the second statement was: "a country that is a crop origin and diversity center (example Brazil: cassava) could use GM versions of this crop (GM cassava)." We used the results of the four-point scale and transformed them into dummy variables if stakeholders agreed with the statement. Roughly 68% of stakeholders agreed that the GM-free country strategy could not improve Brazil's competitiveness in the world market, while 40% prefer to avoid the introduction of GM crops when the country is the diversity and origin center.

Socio-demographic characteristics, such as age (years), education, and religion, were considered as explanatory variables. As a proxy for belief, we used respondents' understanding of the sustainable agriculture, specifically if this production system implies low or zero levels of chemical fertilizers and pesticides. To avoid correlation problems between source information and stakeholder relations, we did not include the former. Stakeholder relationships were included as dummy variables that show the stakeholder relations with main institutions or sectors related to this topic. We expected the same coefficient sign for both equations since both statements reflect a positive attitude towards GMOs.

Many of the socio-demographics are significant and their coefficients have the expected signs (Table 5). In both cases—unsurprisingly—having a PhD is positively and statistically associated with agreeing with the statements (Juma et al., 2007). In our case, older respondents have a more positive attitude towards GM biofortified cassava, which is consistent with findings of Kim and Boyd (2004) and Han and Harrison (2006). Stakehold-

ers who practice a religion are not more likely to have problems with the introduction of a GM version in its center of diversity than non-religious people. In general, the Catholic Church does not have a position against GM technology if it targets the problems of the poor (Nicholson, 2004).

Having relationships with NGOs is negatively associated with agreement with the statement regarding the GM-free strategy for agricultural development. The negative relationship is logical, taking into account that most of the NGO's are the main opponents of these technologies, at both the international and national levels. They have initiated many campaigns to avoid the introduction of GM crops in Brazil, and they were successful up until the Biosafety Law. Currently, they have taken this 'battle' to the consumer level.

As expected, stakeholders with ties to industry support GM crops. This sector in Brazil, as in other countries, has been the key supporter of GMO development (Pray, Paarlberg, & Unnevehr, 2007). Relationships with the research sector are not statically significant. Finally, respondents who believe that a sustainable agriculture implies a low or null level of chemical fertilizers and pesticides are strongly opposed in general to GM foods, though not to GM cassava in particular. Some studies have shown that the more important the role of values, the less important new information becomes in order to shift people's behavior (Costa-Font, Gil, & Traill, 2008); however, according to our results this may not be the case in Brazil.

Conclusions

In general, the perceptions of stakeholders about potential benefits of GM food are positive in Brazil. However, as has occurred in other developing countries, external forces are trying to create a polarization toward this technology. This situation was reflected by the prohibition of planting GM soy for 10 years in Brazil. In 2005, new legislation allowed such crops to be commercially available. Most of the stakeholders think that the law provides adequate orientations for evaluating and monitoring GM crops in Brazil, but efforts to improve the capacity to carry out such activities are needed in order to ensure the biosafety in the country.

According to our results, there are three main groups of stakeholders in Brazilian biotechnology; these groups' positions towards GMOs can be characterized as positive, negative, and pragmatic. Local and multinational industries and part of the government form the biggest group. They have highly positive attitudes towards GM crops for food in general and would support the introduction of a GM cassava enhanced with provitamin A. International and national NGOs form the smallest group; they are more skeptical about the benefits of these technologies. Finally, the remaining group consists mainly of the research sector and has a moderate opinion, which sways positive or negative depending of the particular GM crop. This group is highly trusted by public opinion, which implies that it could play an important role in shaping the broader public perception toward GM food in Brazil.

These results in Brazil confirm the hypothesis that second-generation GM crops are likely to meet with greater public acceptance than first-generation GMOs. However, this acceptance is not unconditional; rather, stakeholders evaluate the tradeoffs between the tangible benefits received by consumers and any potential risks. In the specific case of GM cassava biofortified with provitamin A, two traits are important—the micronutrient increase and the fact that Brazil is a center of origin and diversity for cassava. According to the results of this study, while most stakeholders are generally supportive of GMOs, some question the necessity of a GM strategy for VAD. If these concerns are not addressed, the introduction of cassava with provitamin A in Brazil could face opposition not only from NGOs but also from the more moderate sectors—such as academic and research—whose influence over public opinion may be significant.

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Acknowledgements

The financial support by the International Center for Tropical Agriculture (CIAT) and the HarvestPlus Challenge Program of the Consultative Group on International Agricultural Research (CGIAR) is gratefully acknowledged. We also thank Prof. Matin Qaim, Maria Jose Sampaio, Marilia Nutti, and Deise Capabalo for their support.

Appendix

Perceptions about GM Crops for Food

2.1 The biosafety regulation in Brazil is clear and avoids the wrong use of GM crops in the country.
2.2 Brazilian institutions do not have enough capacity to evaluate and monitor the impact of the GM crops.
2.3 The production of GM crops implies serious ethical problems.
2.4 GM crops are safe for the environment if biosafety guidelines are considered.
2.5 Consuming GM food could be risky for human health.
2.6 GM crops are useful to solve problems that could not be solved by the traditional breeding approach.
2.7 GM food crops could help to ensure the food supply in Brazil.
2.8 To become a 'GM-free country' is a good strategy to increase Brazil's competitiveness in the global markets.
2.9 GM crops could reduce some production costs so that their revenues could increase.
2.10 GM crops developed by national research centers/ enterprises have more public acceptance that those developed by multinationals.

Perceptions about an Introduction of a GM Modified Cassava with More Provitamin A

3.1 The second-generation of GM crops will find more public acceptance in Brazil because of the nutritional qualities that consumers may find appealing.
3.2 A country that is a crop diversity and origin center (e.g., Brazil: cassava) should not use GM versions of this crop (GM cassava).
3.3 Because of the failure to approve GM food crops, consumers in Brazil could lose many nutritional benefits.
3.4 It is better to continue using the current strategies to combat provitamin A deficiency (VAD) than to introduce a complementary tool such as a new GM cassava with more provitamin A.
3.5 A new GM cassava with more provitamin A could have a potential ecological risk.
3.6 The GM cassava with more provitamin A is against the Brazilian culture and traditional knowledge.
3.7 The introduction of a new cassava with more provitamin A is possible in Brazil.