

Commentary

Are all GMOs the same? Consumer acceptance of cisgenic rice in India

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Summary

India has more than 215 million food-insecure people, many of whom are farmers. Genetically modified (GM) crops have the potential to alleviate this problem by increasing food supplies and strengthening farmer livelihoods. For this to occur, two factors are critical: (i) a change in the regulatory status of GM crops, and (ii) consumer acceptance of GM foods. There are generally two classifications of GM crops based on how they are bred: cisgenically bred, containing only DNA sequences from sexually compatible organisms; and transgenically bred, including DNA sequences from sexually incompatible organisms. Consumers may view cisgenic foods as more natural than those produced via transgenesis, thus influencing consumer acceptance. This premise was the catalyst for our study—would Indian consumers accept cisgenically bred rice and if so, how would they value cisgenics compared to conventionally bred rice, GM-labelled rice and 'no fungicide' rice? In this willingness-to-pay study, respondents did not view cisgenic and GM rice differently. However, participants were willing-to-pay a premium for any aforementioned rice with a 'no fungicide' attribute, which cisgenics and GM could provide. Although not significantly different ($P = 0.16$), 76% and 73% of respondents stated a willingness-to-consume GM and cisgenic foods, respectively.

Introduction

India currently has more than 215 million food-insecure people, many of whom are agricultural producers (FAO *et al.*, 2012). In India, rice accounts for more than 40% of total food grain production (Singh *et al.*, 2015), but only 4% of this rice comes from hybrid varieties. This contributes to lower yields under stressful conditions. Genetically modified (GM) crops have the potential to help alleviate this problem by increasing food supplies and strengthening farmer livelihoods (Kathage and Qaim, 2012). For this to occur, however, consumer acceptance of GM foods is critical as the majority of staple crops are consumed domestically. Today, transgenic GM crops are the predominantly grown form of GM; however, given consumer aversion to these in some countries, cisgenically bred crops may be an alternative. Cisgenesis refers to the transfer of genetic material between sexually compatible organisms, while transgenesis occurs between sexually incompatible organisms (Schouten *et al.*, 2006). Several studies have analysed Indian consumers' willingness-to-pay (WTP) for GM products (De Steur *et al.*, 2015), but no such studies have been conducted for cisgenically bred foods. This is an important issue because some researchers and regulatory institutions, such as the European Union, have proposed a less precautionary approach for regulating cisgenic crops as compared to transgenically bred crops (EFSA, 2013). Furthermore, consumers may view cisgenic foods as more natural than

those produced via transgenesis, thus influencing consumer acceptance.

GM technology shows promising results for increasing yields and mitigating biotic and abiotic stress, which could contribute to increased food security (Singh *et al.*, 2015). That being said, GM technology for food crops has not been exploited in India due to a litany of regulatory issues. The Indian Supreme Court placed an indefinite moratorium on commercialization of all GM food crops from 2005 until 2014. Bt (*Bacillus thuringiensis*) cotton (*Gossypium hirsutum*), which was commercialized prior to this moratorium, is the only GM crop currently grown commercially in India and accounts for more than 90% of domestic cotton production. Contrary to critical claims that Bt cotton has led to increases in farmer suicides and lower profits, several studies have shown that Bt cotton has led to fewer cases of pesticide poisoning, an overall decline in suicides among cotton farmers, and increased cotton yields per hectare by more than 20% (Gruère *et al.*, 2008). Unlike cotton, a fibre crop that is not cultivated for direct human consumption, staples such as rice (*Oryza sativa*) are field-to-plate crops, which tend to make GM acceptance a larger barrier.

The Genetic Engineering Approval Committee (GEAC) approved Bt eggplant (*Solanum melongena*) for commercialization in 2009, but the decision received strong dissent from several nongovernmental organizations. Subsequently, the Ministry of Environment and Forestry overruled the GEAC and called for the moratorium on the commercialization of GM crops to continue. In 2014, this moratorium was lifted, but the current status of

commercialization of GM food crops in India remains tenuous due to scepticism and continuous activism against GM by lobbyist groups. Therefore, consumer preferences could have a considerable impact on the regulation and adoption of GM crops.

The rice blast (*Magnaporthe oryzae*) fungus is responsible for up to 30% of the losses in rice production globally and therefore is a key concern in combating food insecurity (Skamnioti and Gurr, 2009). It has been estimated that worldwide, the annual loss of rice to blast could feed more than 60 million people.¹ Cisgenically bred rice has the potential to alleviate the effects of rice blast without increasing the use of fungicides, and if widely adopted, there would likely be a decrease in fungicide use in rice production where blast is a common problem. In this case, cisgenic rice would be produced via the insertion of a rice blast resistance gene (*PI9*) from a low-yielding wild rice variety (*Oryza minuta*) into a high-yielding and widely cultivated variety (Qu *et al.*, 2006). Cisgenic crops are produced by the same transformation technologies (*Agrobacterium*-mediated transformation or biolistic transformation) used for producing transgenic plants. The difference is that the entire inserted gene (including promoter, coding sequence, intron and terminator sequences) is naturally found in rice or another sexually compatible plant. Any selection marker gene used in the transformation process is removed so that no foreign DNA sequences remain in the cisgenic plant.

This study is unique because no other study has examined Indian consumers' acceptance and WTP for cisgenic vs. GM crops. This is an important issue as consumers may view cisgenic foods as more natural than food produced via transgenesis. Hence, this study attempts to answer this important question—would Indian consumers accept cisgenically bred rice and if so, how would they value cisgenics compared to conventionally bred rice, GM-labelled rice and 'no fungicide' labelled rice?

Survey design and experiment

We administered a consumer survey in India replicating the WTP approach in Delwaide *et al.* (2015), which assessed consumers' attitudes towards cisgenic rice in western Europe. We modified the survey instrument to be applicable in the Indian context, translated it into Hindi and conducted 300 interviews between November 2014 and February 2015 in Jaipur. Interviews were conducted face-to-face in socio-economically distinct areas of Jaipur in an attempt to mimic a random sample of the city. Surveys were administered to different age groups and people with differing educational status and income levels. The two interviewers utilized remote internet access to upload responses during each interview.

Participants responded to three information sets. In each information set, respondents were asked to choose between an alternative long-grain nonfragrant rice variety and a conventional long-grain nonfragrant rice variety priced at varying levels. For the purposes of this study, 'cisgenic' was described as 'bred using a process in which genes are transferred between crossable organisms (same species or closely related species). The same result could be obtained by cross-breeding that occurs in nature or by traditional breeding methods but it would require a longer time frame'. In the GM treatments, participants were asked to choose between a GM and conventional rice without a specific

definition for GM. The 'no fungicide' alternative was described as follows: 'New breeding techniques can result in a rice variety that is resistant to rice blast disease and would not require fungicide sprays. Rice blast is a disease that decreases yields and increases greenhouse gas emissions because of the fungicide sprays that are required to treat the disease'. Additionally, respondents were told the alternative and conventional varieties had equal quality. In the initial information round, the alternative rice variety was described as having one of the three aforementioned attributes—GM, cisgenic or 'no fungicide'—assigned randomly. In the following round, one of the two missing attributes from the initial round was randomly chosen and combined with the first-round attribute. In the final round, participants were presented an alternative rice that had all three attributes—GM, cisgenic and 'no fungicide'.

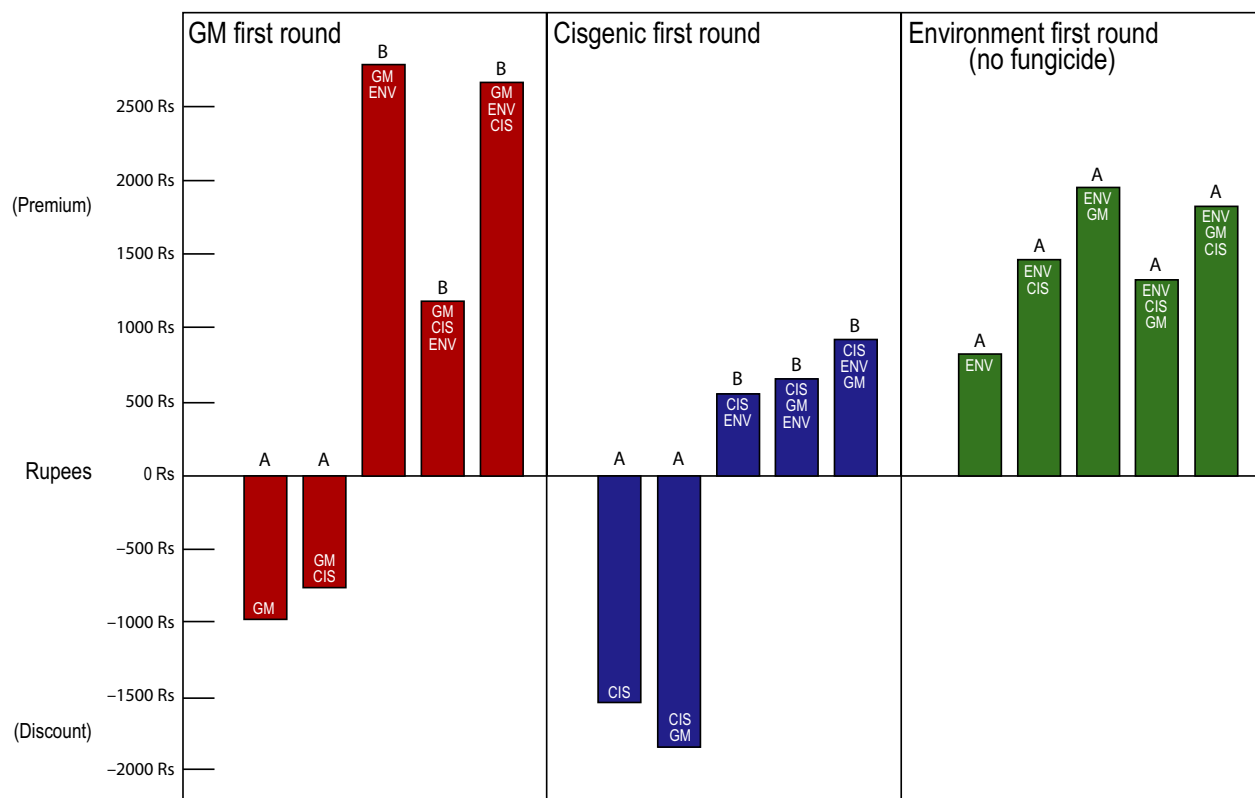
The alternative (variously described) rice varieties were presented at a constant value of 175 rupees per five-kilogram bag, and the conventional rice variety was shown starting at 3,850 rupees per five-kilogram bag. If the respondents chose the alternative rice variety, then the conventionally bred variety became incrementally cheaper moving through intervals from 3850 rupees to 1520, 1150, 750, 580, 350, 230, 175, 150, 85 and 35 rupees. Each information round terminated when the respondents selected the conventional variety at a price greater than 35 rupees or when the price was 35 rupees. After the three rounds were completed, demographic information on gender, age, education and income was collected. Using an interval regression model, price premiums and discounts were estimated based on the price intervals in which consumers selected the conventional variety. Bonferroni statistics were used to assess the statistical differences among consumer WTP given varying descriptions of the alternative rice. In concluding the survey, consumers were asked whether they would consume GM food and cisgenic food more generally, with response choices of 'yes', 'no' and 'not enough information to decide'. We then asked respondents to choose between two contrasting statements regarding the labelling of cisgenic rice as 'Genetically Modified'.

Consumers' valuation of cisgenic vs. GM vs. 'no fungicide' rice

Survey respondents were willing-to-pay a premium for the 'no fungicide' alternative variety when presented without GM or cisgenic attributes (Fig. 1). Respondents were also willing-to-pay similar premiums when the GM and cisgenic alternatives were described with the 'no fungicide' attribute. Whenever the 'no fungicide' descriptor was present in an information round, consumers would pay a premium, with no statistical distinction between the premiums for 'no fungicide' and GM or 'no fungicide' and cisgenic combinations. Overall, consumers did not view GM and cisgenic alternatives as substantially different from one another, and consumers required discounts for both GM and cisgenic rice when the 'no fungicide' attribute was absent in the description.

Findings indicate that 73% of respondents said they would consume cisgenic food, and 76% would consume GM food. This difference in participants' willingness-to-consume GM and cisgenic foods was insignificant ($P = 0.16$). On average, 88 per cent of respondents believed that cisgenic rice should have a GM label. These results are particularly interesting when compared to Delwaide *et al.*'s (2015) findings in western Europe where only 38 and 36% of respondents would consume cisgenic and GM

¹<http://www.agribusinessweek.com/rice-disease-seriespart-2-rice-blast/>



1.) Interval regression model controls for gender, age, education, and income.
2.) Within each of the three panels, bars with different letters are statistically different from one another at $P < 0.05$.

Figure 1 Consumers' willingness-to-pay for GM, cisgenic (CIS) and 'no fungicide' (ENV) rice compared to a conventional rice variety.

foods, respectively. Similar to Indian consumers, 84% of Europeans believed cisgenic foods should be identified with special labels.

Discussion

Our study results generally imply that (i) Indian consumers are willing to eat both cisgenic and 'GM' rice, albeit at a discount; (ii) from a consumer perspective, cisgenic and GM products should not be regulated as distinct from one another in India; (iii) cisgenic and GM foods should be labelled as such; and (iv) labelling GM and cisgenic foods as 'no fungicide' may enhance the marketability of GM rice in India. As this study only focused on one city in India, the Indian government may consider implementing similar surveys nationwide to test the robustness of our findings, especially with the broad array of GM applications available for the agricultural sector. Based on this survey, policymakers should take into account the proportion of consumers' willing-to-consume cisgenic food, as well as the fact that consumers do not distinguish between cisgenesis and transgenesis in their choices. In this regard, it appears consumers would be open to GM products competing in the open market. Given India's recent and favourable changes to the regulatory protocols for GM crops, the high level of food insecurity, and the overwhelming stresses faced by Indian farmers, GM technology could be a boon on a number of fronts for the country. However, this is most likely true only if they are available at a discount or presented with particular attributes, such as 'no fungicide', which may be deemed more appealing by consumers.

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Conflict of interest

The authors declare no conflict of interest in producing this article.

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