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A consumer segmentation study with regards to genetically modified food in urban China

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ABSTRACT

The objective of this study is to identify the underlying subgroups of Chinese consumers in terms of their perceptions and attitudes toward GM foods. In particular, we address the following specific questions: may researchers segment Chinese urban consumers in terms of their attitudes and perceptions toward GM foods? Are there any relationships between segmented consumer groups and other factors – such as their exposure to GM knowledge and socio-demographics? And, what policy implications can be drawn from this research to the future biotech development in China? Based on a large-scale survey data collected by the authors in 2002 and 2003 in 11 cities of China, this research applies consumer research methodologies. The combination of factor and cluster analysis enables us to identify successfully and consistently four Chinese consumer clusters based on their perceptions and attitudes toward GM foods, which include a food safety cluster, a nutritional technologist cluster, a GM skeptic cluster, and a cluster of GM for non-food promoter.

Introduction

Over the past three decades, China has developed the largest public biotechnology sector outside of North America (Huang et al., 2002a). Chinese scientists have generated an impressive array of new genetically modified products (commercialised and in trials), that includes cotton, rice, wheat, maize, soybean, potato, tomato, papaya, sweet pepper, etc. Recently, the Chinese government approved a National Special Program on the Genetically Modified Crops and Livestock Breeding with funding reaching US$3.9 billion (or RMB 26 billion).

The benefits of GM technology to Chinese producers have been widely documented, including the environmental gain (Huang et al., 2002a,b; Wu et al., 2008). However, studies on Chinese consumers' segmentation toward GMO foods have been neglected to a large degree. Several studies suggested that Chinese consumers have a higher acceptance rate towards GM foods when compared with consumers in other countries (Gale et al., 2002; Li et al., 2003; Huang et al., 2006). However, most consumer studies in China to date focused on consumers' acceptance and willingness to pay for biotech foods (Lin et al., 2006a,b). We have not found any consumer segmentation studies reflecting consumer attitude towards GM products.

Consumer segmentation studies go beyond the division of two categorical consumers, accepting and refusing GM products, and provide much insight into consumers' underlying attitudes. In their Eurobarometer survey of 17 European countries, Gaskell et al. (2004) categorized the sample into four groups: (1) trade-off consumers perceiving both risks and benefits; (2) relaxed consumers perceiving benefits and no risks; (3) sceptical consumers perceiving risks but no benefits; and (4) uninterested consumers perceiving neither risks nor benefits. Based on consumers' preferences on product attributes such as brand, price and GMO content, Baker and Burnham (2001) classified three consumer clusters in the USA, including brand buyers, safety seekers, and price pickers. Using the results recorded from consumers' attitude statements, Kaye-Blake et al. (2007) distinguished six clusters in New Zealand, namely price sensitive, true believing, appreciative, middle of the road, opposed, and concerned. Christophe et al. (2008) identified three clusters of supporters, opponents and indifferent consumers based on five factors describing consumers' attitudes towards genetic modification. These studies indicate that modern consumers are sophisticated. Their perception and attitude towards risks and benefits may emanate from various factors that include their social demographic variables, trust, lifestyles, etc.

The overall goal of this paper is to identify the underlying subgroups of Chinese consumers based on their perceptions and attitudes toward GM foods. In particular, we will address the following three questions: (1) may Chinese consumers be segmented in terms of their attitudes and perceptions toward GM

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foods? (2) Are there any relationships between segmented consumer groups and other factors such as their GM knowledge and socio-demographics? And, (3) what policy implications can be drawn from this research to enrich the future biotech development in China? Because the data used in this study was taken from surveys conducted by the authors in urban environments, we limit our study to perceptions in urban China. The paper is organized as follows. 'Data and methodology' discusses the data, sampling and methodology used in this study. The results of surveys and analyses are presented in 'Results'. The final section presents the conclusions drawn from the study.

Data and methodology

Data and survey

The study makes use of a large-scale survey carried out in 11 cities in China in 2002 and 2003. Among others, this survey examined consumers' GM knowledge, attitudes towards as well as willingness to purchase GM foods. The sample is a sub-set of the Urban Household Income and Expenditure Survey (UHIE) conducted by the National Bureau of Statistics of China (NBSC). NBSC's UHIE covers 226 cities across China with about 250 thousand randomly selected households, which represent a cross section of China's urban consumers. This data has been collected as the official source of information on the urban income and expenditure and has been widely used by scholars for various empirical studies. Normally, NBSC replaces about one-third of its sample population each year.

Our surveys were conducted in 11 cities under NBSC's UHIE survey in North and East China, cities which together account for about 40% of the national population and nearly half of China's urban residents. Within each of the North and East regions, we applied a stratified random sampling approach to further select our survey areas from UHIE's sample cities to insure that our samples well represent urban consumers in these two regions. Two large, three medium and six small-size cities were selected. The total samples under NBSC's UHIE survey in these 11 cities are 2300.

We conducted two rounds of surveys, one in 2002 and the second in 2003. In 2002, we randomly selected 1005 individuals from 2300 UHIES's samples in 11 cities for person to person and in-house interviews. To avoid potential selection bias in the individuals interviewed in each household, the enumerators were asked to interview an adult (ages 16–70) whom they met first when they came to the interviewee's apartment. The interviews were conducted by the authors and by professional enumerators from each provincial branch of NBSC. In 2003, we returned to the same cities and endeavoured to indentify the same interviewees. Our intentions were to repeat a similar survey whilst introducing additional questionnaires and to identify the changes of their attitudes on GM foods over the past year. Because NBSC replaces one-third of its UHIE samples each year, we were able to interview only 666 individuals who were interviewed in 2002 and another 334 new households randomly selected from UHIES's new samples in the same cities in 2003.

In this study, a total of 1000 responses were used, including the 666 responses from the first round survey in 2002 and the new 334 responses from the second round survey in 2003. Our choice to omit the remaining 339 sample responses from 2002 is due to some key additional information added. For example, whether the consumers believe in government competence in public management is a relevant example of questions used in this study, and not included in the 2002 survey. The other 666 samples were traced back to the 2003 survey and complete all the additional information required for this study. But with respect to the data on attitudes to GM foods, of the 666 samples that were interviewed in both 2002 and 2003, we only used attitude information from the 2002 interviews in this study. We took this decision after noting that their attitudes towards GM food showed some changes in 2003 over 2002. This[1] could be partially due to the effects of the survey we conducted in 2002. The new 334 samples in 2003 were also used, given that we held all the information needed of those samples.

Exploratory factor analysis

Due to a large number of questions covering a wide range of issues, we first used factor analysis to narrow down the number of variables and to define the underlying structure in the data matrix. An exploratory factor analysis was applied to 25 statements measured in a five-point Likert scale from "completely acceptable" to "strongly opposed", or "very much important" to "very unimportant". The appropriateness of the factor model was evaluated by the measurement of sampling adequacy (MSA), Kaiser–Meyer–Olkin (KMO) test and the Bartlett test of Sphericity (Hair et al., 1995). After the data examination, a principal component analysis was carried out.

Cluster analysis

After the factor analysis, the factor scores were saved for each factor. The newly derived five factors replaced the original 25 statements as a new dataset for the subsequent step in cluster analysis. Cluster analysis was used to identify groups of individuals and define them in clusters so that individuals in the same cluster were more similar to one another than they were to individuals in other clusters. This methodology has been widely used in segmentation studies (Baker and Burnham, 2001; Kornelis et al., 2007; Zhang et al., 2008).

In the first step of cluster analysis, a Hierarchical cluster procedure was conducted to determine the number of clusters with a random sample of 200 respondents. By examining the agglomeration coefficients with the successive steps of the hierarchical cluster procedure, an elbow graph[2] of four clusters were found. Accordingly, K-means cluster procedures were applied by taking the cluster seeds generated from the Hierarchical analysis as the initial cluster centres. Each case was assigned to the nearest of the four clusters using Euclidean distance. This process was iterated until convergence. In order to better understand and profile these four clusters, a series of ANOVA tests were carried out to relate the mean values of these clusters with consumers' demographic characteristics, their knowledge and their willingness to purchase GM foods.

Results

Demographic characteristics

Table 1 shows the socio-demographic characteristics of the total survey sample in 2002 and 2003, which include household characteristics and respondents' individual characteristics. When comparing our drawn sample with the large sample as calculated in Huang et al. (2006), the household profiles are shown to be almost identical except for a slightly higher income in our 2003 sam-

[1] Qiu (2005), using the 666 samples who had been interviewed both in 2002 and 2003, shows that consumers who would accept pest-resistant GM fruit/vegetable increased from 63% in 2002 to 73% in 2003, and the acceptance to pest-resistant GM rice increased from 61% in 2002 to 72% in 2003, and the acceptances to other GM foods have no significant changes between 2002 and 2003.

[2] An elbow graph is a visual presentation by plotting the agglomeration coefficients on the successive steps of the hierarchical cluster analysis. The final solution of cluster numbers is decided on the elbow revealed.

Table 1
Characteristics of respondents in 2002 and 2003. *Source*: Author's survey.

	2002 (n = 666)		2003 (n = 334)	
	Mean	Standard deviation	Mean	Standard deviation
Household characteristics:				
Household size (persons)	3.0	0.7	3.0	0.8
Monthly income per capita (yuan)	841	415	1128	858
Residence city (%):				
Small size city	30		30	
Medium size city	32		33	
Large size city	38		37	
Respondent's characteristics:				
Share of male (%) respondents	41	49	45	50
Age (years)	47	11	47	12
Education (years)	11	3	11	3
Occupation (%)				
Government	23	40	22	40
Enterprises	44	47	38	47
Unemployed	9	27	10	32
Retired and other	24	42	30	47

ple. Furthermore, Huang et al. (2006) compared the demographic variables from the large sample with the data from the National Bureau of Statistics in China. The household characteristics from the sample, such as household size and per capita monthly income, were almost the same as national average for urban consumers/households in the same year. Therefore, the results of this study can be generalized to urban China.

Consumers' knowledge and attitudes towards GM foods

A basic quiz of six questions concerning biotechnologies was given to respondents. The comparison of the test results among China, US and EU were presented in Table 2. Among the six questions, the one with the highest proportion of correct responses was answered correctly by 93% of the respondents. The two with the smallest proportion were answered correctly by less than 30 of the respondents. The remaining three questions were answered correctly by about half of the respondents. We conducted chi-square tests between countries for the purpose of international comparison. Tests show that there are statistical differences between Chinese consumers and EU consumers in four of the five statements (last column, Table 2). This indicates that Chinese consumers are more knowledgeable regarding issues concerning biotechnology than their EU counterparts whilst remaining less knowledgeable about biotechnology issues than consumers in the US (column 5, Table 2). It remains a universal phenomenon that consumers have very limited knowledge regarding biotechnology. This suggested that consumers' attitudes toward GM foods could be influenced by new information supplied and knowledge gained.

Consumers' attitudes toward the specific GM foods are presented in Table 3. The results indicated that a majority of Chinese urban consumers were supportive of GM foods. The pro-biotech group (combining completely acceptable with relatively acceptable) accounted for 46–67% of all respondents, while 6–14% of urban consumers were opposed to GM foods to different degrees. One quarter of the rest of the consumers held a neutral position or had no opinion yet towards GM foods. At any international comparison level, the acceptant rates of GM foods in China were quite high. We further tested whether the consumer's acceptability profile are different across the six group products by using chi-square statistics. The test results in Table 4 show that there is no difference between consumer's attitudes towards group 1 products 'The pest-resistant GM fruit/vegetables' and group 4 products 'The disease-or-pest-resistant GM rice'. This result comes as no surprise since these two group products deal mainly with food safety issues. Other similar attitudes are found between product groups 1 and 5, and groups 2 and 3. The remaining results indicate different consumer attitudes across product groups.

Searching for factors

A factor analysis was first used for the 25 attitudinal statements to identify a relatively small number of factors that can be used to represent relationships amongst the 25 interrelated variables. The

Table 2
The comparison of biotechnology knowledge quiz among China, US and EU. Source: adapted from Huang et al. (2006)

Quiz statements	Percentage of persons answered correctly in:			Chi-square test (P value)[d]	
	China[a] (2002)	US[b] (2003)	EU[c] (2002)	China-US	China-EU
1. There are some bacteria which live on wastewater (True)	93	94	84	0.342	0.000
2. The father's genes determine whether the child is a boy (True)	58	73	53	0.000	0.002
3. Ordinary tomatoes do not contain genes, while GM tomatoes do (False)	43	57	36	0.000	0.000
4. If a man eats GM fruits, his genes could be modified as a result (False)	53	69	49	0.000	0.014
5. It is impossible to transfer animal genes to plants (False)	26	48	26	0.000	1.000
6. Tomato genetically modified with fish genes would taste "fishy" (False)	29	60	NA	0.000	NA

Note: In US and EU, instead of asking the question of 'the father's genes determine whether the child is a boy, they asked 'the mothers' genes determine whether the child is a girl.
[a] The authors' survey in 2002.
[b] Hallman et al. (2003).
[c] Gaskell and Allum (2003).
[d] The sample size is 1000 respondents for China, 1200 for US and 16,900 for EU.

Table 3
Consumers' attitudes toward the specific GM foods (%). *Source*: The author's survey. Sample size is 1000 respondents.

	Completely acceptable	Relatively acceptable	Neutral	Relatively opposed	Strongly opposed	Undetermined
The pest-resistant GM fruit/vegetable	24	42	20	7	1	6
The longer shelf-life GM fruit/vegetable	16	37	29	10	2	6
Oil from GM soybeans	13	38	28	11	2	8
The disease-or pest-resistant GM rice	23	42	19	9	1	7
The nutrition improved GM rice	25	42	21	5	1	6
Livestock fed by GM maize	13	33	30	11	3	10

Table 4
Chi-square statistics for response categories and product groups. *Source*: The author's survey. Sample size is 1000 respondents.

Product groups	1. The pest-resistant GM fruit/vegetable	2. The longer shelf-time GM fruit/vegetable	3. Oil from GM soybeans	4. The disease-or pest-resistant GM rice	5. The nutrition improved GM rice	6. Livestock fed by GM maize
1. The pest-resistant GM fruit/vegetable	–					
2. The longer shelf-life GM fruit/vegetable	0.000	–				
3. Oil from GM soybeans	0.000	0.076	–			
4. The disease-or pest-resistant GM rice	0.248	0.000	0.000	–		
5. The nutrition improved GM rice	0.064	0.000	0.000	0.000	–	
6. Livestock fed by GM maize	0.000	0.003	0.016	0.000	0.000	–

appropriateness of the factor model was evaluated by several criteria. The data matrix is approved to be suitable for factor analysis as the Bartlett's test of Sphericity is highly significant, while the KMO measure was 0.906, a very strong result of sampling adequacy measurement (Hair et al., 1995).

Principal component analysis was used to extract the factors. After applying a Varimax rotation, five factors were derived, which explained 58% of the total variance. The factor loading (only top ones were shown) of all 25 statements are presented in Table 5. Because the factor loadings were the correlations of the original variables and the derived five factors, they played important roles in the interpretation of these factors. Thus variables with higher loadings, such as above 0.70, influenced to a great extent the name or label assigned to represent a factor. The first factor was named as "Benefit" since these higher loading items indicated consumers' attitudes towards the expected benefit of GM foods for consumers, the public, and the environment. Statements in factor 2 referred to the creation process of GM food and summarized consumers' attitudes toward the production process of using genetic modification technologies. So "Process" was a suitable name. The third one was named "Trust" as these statements showed the trust and belief in the society and indicated respondents' attitude towards the government and scientists. Several studies in the EU and US pointed out that trust in government could play an important role in shap-

Table 5
Rotated factor loadings for five factors.

	1: Benefit	2: Process	3: Trust	4: Intrinsic quality	5: External traits
Disease or pest-resistant rice	0.84				
Disease or pest-resistant GM vegetables or fruits	0.82				
Soybean oil from GM soybeans	0.80				
Long shelf-life GM vegetables or fruits	0.77				
Nutrition improving GM rice	0.75				
Pork fed with GM maize or soybean	0.74				
GM plant food created from a microbe into a crop		0.77			
GM plant food created from another species plant into a crop		0.74			
GM seafood		0.71			
GM livestock		0.70			
GM plant food from an animal body into a crop		0.68			
GM edible products		0.65			
GM inedible products		0.63			
Government attitude towards the low-level people group			0.78		
Trust in government ability			0.78		
Self care towards the environment or biodiversity			0.57		
Trust in the work of the biotechnologist			0.46		
Trust in multinational companies			0.38		
The importance of food taste				0.75	
The importance of freshness				0.65	
The importance of reduced pesticide residue				0.59	
The importance of nutrition				0.52	
The importance of price					0.79
The importance of shelf life					0.66
The importance of cleanliness					0.46

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ing public attitudes towards GM food, largely via its links to risk perceptions (Curtis et al., 2004; Hossain and Onyango, 2004; Wolf et al., 2004). The last two factors were named as "Intrinsic Quality" and "External Traits" since they clearly described different attributes at product level. The fourth factor "intrinsic quality" referred to consumers' attitudes in the essential features of agrifood, while the last factor "external traits" signaled their outer quality.

Consumer segmentations

To identify consumers segments based on respondent attitudes, a two-step cluster approach (Hierarchical and *K*-means cluster analysis) was conducted based on the factor scores from principal component analysis. Finally four clusters were identified and the number of cases in each cluster is shown in Table 6. These four clusters carry cluster memberships of 31%, 14%, 26% and 29% of the respondents, respectively. In order to further test the validity of the four clusters, we ran both an ANOVA test and a Post Hoc test. The ANOVA test indicates all results reaching the highly significant 1% level. The Post Hoc test is conducted by using Turkey's honestly significant differences (HSD) procedure which allows for pair wise comparisons between the four groups. The Turkey HSD test shows that only 78 out of 336 multiple comparisons are not significant at 1% level. These results indicate that our segmentation of the four clusters was satisfactory and robust.

Table 6
Percentage of cases in each cluster.

Cluster names	Percentages (%)
1. Food safety	31
2. Nutritional technologist	14
3. GM Skepticism	26
4. GM for non-food promoter	29

The next step was to interpret the clusters by assigning a label that accurately described the nature of the clusters. As our cluster analysis was performed using factor scores from factor analysis, we interpret the clusters from both the original questions as well as from underlying factors. We first returned to the raw scores for the original questions and computed average profiles using the original attitudinal data. The average score profiles on the 25 attitude statements for each cluster and their sample means were calculated and are presented in Table 7. Given the large number of statements, it is a challenge to assign a descriptive label to each. At the interpretation stage, we focused mainly on the differences between the group means. The scores on clusters 1 and 2 were quite similar and they were modest supporters to GM biotechnology. However, respondents in Cluster 1 paid a higher attention to pesticide and disease related statements as the scores indicate in statements 7, 8 and 11. We therefore labeled Cluster 1 as "food safety". This group also held the highest level of trust in government and scientists (statements 16–18). Cluster 2 was named as "Nutritional Technologist" since these respondents chose a high value of importance towards GM technology to improve nutrition in rice (statement 12). Cluster 3 were named "GM Skepticism" as they produced high scores from different types of GM foods (from statements 8 to 13) to different the processes of applying GM technology (from statements 19 to 25) all along the line. Furthermore, members in Cluster 3 took significant care and concern with regards to food quality in general (statements 2–6) alongside their concern regarding the environment and biodiversity (statement 15). Respondents in Cluster 4 took a neutral position towards different GM foods (statements 8–13), but showed an interest in innovative GM technologies (statements 19–25). They welcomed in particular the application of GM technology for inedible prod-

Table 7
Clusters means for attitudinal statements.

	1. Food safety	2. Nutritional technologist	3. GM Skepticism	4. GM for non-food promoter	Sample means
1. The importance of price	2.42	2.63	2.06	2.77	2.46
2. The importance of cleanliness	2.09	3.05	1.90	2.46	2.28
3. The importance of food taste	1.57	2.94	1.55	1.78	1.82
4. The importance of nutrition	1.41	2.07	1.34	1.81	1.60
5. The importance of freshness	1.16	1.93	1.18	1.35	1.33
6. The importance of shelf life	2.81	3.63	2.53	3.05	2.92
7. The importance of reduced pesticide residue	1.14	2.36	1.19	1.23	1.35
8. Disease or pest-resistant GM vegetables or fruits	1.70	1.91	2.72	2.24	2.15
9. Long shelf-life GM vegetables or fruits	2.09	2.11	3.02	2.42	2.43
10. Soybean oil from GM soybeans	2.08	2.24	2.89	2.50	2.44
11. Disease or pest-resistant rice	1.76	1.87	2.76	2.30	2.19
12. Nutrition improving GM rice	1.76	1.62	2.65	2.22	2.11
13. Pork fed with GM maize or soybean	2.28	2.18	3.11	2.50	2.54
14. Government attitude towards the low-level people group	2.75	2.22	1.85	2.63	2.41
15. Self care in environment or biodiversity	2.51	2.02	1.70	2.02	2.09
16. Trust in government	2.64	1.80	1.81	2.42	2.25
17. Trust in multinational companies	2.84	2.47	2.57	2.78	2.70
18. Trust in the work of biotechnologists	1.97	1.72	1.83	1.74	1.83
19. GM plant food created from another species plant in a crop	2.33	2.21	2.80	1.84	2.29
20. GM plant food from an animal in a crop	3.03	2.72	3.29	2.42	2.87
21. GM plant food created from a microbe in a crop	2.80	2.59	3.15	2.12	2.66
22. GM edible products	2.31	2.22	2.85	2.10	2.37
23. GM inedible products	2.25	2.20	2.54	1.71	2.16
24. GM livestock	2.74	2.57	3.16	2.27	2.68
25. GM seafood	2.73	2.52	3.19	2.23	2.67

Note: All statements are measured in five-point Likert scale, but slightly different wordings. Statements 1–7 are from "very important" to "'very unimportant". Statements 8–13 and 19–25 are "completely acceptable" to "strongly opposed". Statements 14 and 15 are from "very much care" to "very much uncare". Statements 16–18 are from "very much believe" to "very much doubt".

Table 8
The means of the factors scores by four clusters.

Factors	1. Food safety	2. Nutritional technologist	3. GM Skepticism	4. Non-food GM supporter
1. Benefit	0.64	−0.52	0.40	0.59
2. Process	0.35	0.30	−0.96	0.51
3. Trust	0.58	−0.42	0.24	−0.75
4. Intrinsic quality	−0.41	1.63	−0.01	−0.37
5. External traits	−0.08	0.40	0.28	−0.48

Table 9
Characteristics of the four clusters. *Source*: Authors' survey.

Clusters	GM knowledge correct answers	Monthly per capita income (Yuan)	Education years	Willingness to purchase
1. Food safety	2.95	805.27	11.65	4.84
2. Nutritional technologist	2.64	932.06	10.93	5.13
3. Skepticism	2.86	1077.31	11.97	3.47
4. GM for non-food promoter	2.79	1100.94	11.73	4.66
Average	2.84	936.44	11.65	4.49
F-test significant level	0.152	0.001	0.070	0.000

ucts (statement 23). Thus the label "non-food GM supporter" was chosen.

As the four clusters are derived from the five underlying factors, we expect that the means of the factor scores differ across the clusters. As Table 8 indicates, the food safety cluster has the highest scores in factors benefit and trust. This points out to us that consumers in the food safety cluster are aware of the benefits of GM technology in reducing disease and pest problems and that this group hopes to see an improvement in food safety by reducing pesticide use in crop production through the adoption of GM technology. The highest factor scores for cluster Nutritional Technologist is Intrinsic Quality, a strong indication that consumers value the applying GM technology to improve the intrinsic quality of food, such as taste and freshness. Members in the GM Skepticism cluster have the highest negative score on Process factor, an indication that consumers in this group strongly oppose transgenetic research between difference species. The last cluster non-food GM supporters have lower scores in the factor Trust. They are doubtful regarding "the works" of government and scientists and all show negative scores on GM's application to improve the intrinsic quality and external traits regarding food. This is the main reason they prefer non-food GM applications.

The successful segmentation of four clusters provided more detailed information regarding the Chinese consumer society. The first cluster food safety, which accounts for 31% of urban consumers (Table 6), was primarily concerned with pesticide residues. They hoped to apply GM technology to solve disease and pest problems. It is not surprising that the largest consumer group belongs to this cluster given that large quantities of pesticides are used in production and there is almost no traceability in the marketing system.[3] Consumers in the second cluster hoped that GM technology would directly benefit consumers by improving the nutritional values, the so-called second generation of GM technology (Fernandez-Cornejo et al., 2006). Consumers in the third cluster appeared skeptical toward GM. They showed a higher level of concern with regards to food quality, they perceived a low level of benefit from GM technology, and were concerned with regards to GM production process and negative effects on the environment. The final cluster took the middle of the road stance and they showed to be indifferent towards GM foods. However, they showed notable support for GM technology in non-food applications.

After naming each of the four clusters, we profiled them further by assessing their relationships with respondents' knowledge with regards to GM technology, their willingness to purchase, and a number of socio-demographic variables such as income, education, age and gender. The respondents' knowledge was assessed by the sum of correct answers on the six questions on the biotechnology knowledge. The measurement of willingness to purchase was the sum of the willingness to purchase any of the six different GM products as indicated in statements from 8 to 13 under the condition that the prices were the same for GM and non-GM products. They are measured in five-point Likert scale from 'strongly willing' to 'strongly unwilling'. The ANOVA test results of their differences among the four clusters were presented in Table 9. The results show that the three factors (incomes, education and willingness to purchase) were statistically significantly different amongst the four clusters at various levels of significance, whilst the difference in biotechnology knowledge level is not statistically significant. The chi-square from cross tabulations for gender difference is similarly not significant. These findings are consistent with studies by Lin et al. (2006a,b), where they found that demographic variables, such as gender and age, play little role in determining consumers' acceptance of biotech food in China, with the exception of those consumers with increased disposable income. The cluster "GM for non-food promoter" enjoyed the highest per capita monthly income whilst the income from the "food safety" cluster was the lowest: a strong indication that the rich and the poor may have different concerns in China. Apparently, the knowledge level for all respondents was quite low. The correct answers for all four clusters were less than half, which may explain the reasoning of the non-significance. It is interesting to point out that the Cluster 2 Nutritional Technologist group had the highest willingness to purchase GM foods, followed by the Cluster 1 food safety group. It was not surprising to find that the Skeptical group had the lowest tendency to purchase GM foods.

Conclusions and policy implications

Past studies revealed that Chinese consumers' acceptance of, and willingness to buy GM foods, are much higher than those in most other countries (IFIC, 2004; Gaskell et al., 2006; Christophe et al., 2008). Several regression analyses carried out also indicated that income plays an important role in consumers' acceptance of GM food in China. The combination of factor and cluster analysis enables us to identify successfully and consistently four Chinese consumer clusters based on their perceptions of, and attitudes towards, GM foods.

The analysis identified four segments; suggesting that urban Chinese consumers are sophisticated and each segment has different concerns and interests towards GM products. The food safety cluster has the lowest income and is more concerned with pesticide residues on vegetables and fruits. Their willingness to buy GM foods is quite high since they see GM technology as the best current solution to prevent plant diseases and reduce pesticide use. The Nutritional Technologist has the higher probability of buying GM foods as they see the direct nutritional benefits that GM technology can bring to consumers. The biggest "worriers" concerned with GM technology is the Skepticism cluster. This group

[3] A recent study by Huang et al. (2008a) shows that whilst China's agricultural market is very competitive with millions of small farms and small traders, products are vulnerable to food safety problems. With most of the transactions being characterized as pure spot market, there is almost no traceability in the system.

shows the lowest potential to purchase GM foods. The last cluster GM for non-food promoter enjoys the highest income, is less concerned about food, but is more concerned and shows greater interest in non-food application of GM technology, such as in medicines.

As the Chinese government is launching another phase of the GM crop and livestock initiative, it is paramount for policy makers as well as the private sectors to understand Chinese consumers better. Different GM technologies and market strategies are needed to target different consumer groups. When focusing on Cluster 1 consumers, it is important to stress the benefits of GM foods for resolving food safety problems. Cluster 1 consumers are the most important segment of consumers as they account for nearly one-third of urban population. Given the vulnerability of food safety in China's market (Huang et al., 2008a), the first generation of GM technology primarily focused on insect and disease resistance should be continued: it will assist China in improving its food safety and will meet consumers' demand for less pesticide residuals in food.

When dealing with the Cluster 2 group, the quality improvement of food, such as nutrition, freshness, taste, etc. should be the priority. This implies that the second generation of GM technologies will well meet the demand of Cluster 2 consumers. Although this group of consumers accounts for only 14% of China's urban population, they rank as number one in their willingness to purchase GM food.

Consumers in Cluster 3 are basically opposed to GM food. Although, the share of the urban population belonging to this cluster was only about 26% in 2002–2003, (a percentage which is significantly much lower than in many other countries surveyed), these consumers should be target consumers to whom the government should pay particular attention on efforts to ease their worries and concerns on the safety of GM foods and on environmental and biodiversity issues. As an example: although China already has a comprehensive agricultural GM biosafety regulatory and monitoring system (Huang et al., 2008b), the biosafety evaluation and approval procedure require more transparency to enable consumers, particular those belonging to Cluster 3, to better understand biosafety issues and improve their trust in government's ability to regulate GM technology and to allow only GM technologies that are safe to human health and to the environment to be introduced. China's GM food labeling policy is also expected to have an impact on their willingness to purchase GM food. In response to the presence of GM foods in the market, labeling in China is a compulsory requirement.[4] The impact of compulsory labeling policy on the attitudes of Cluster 3 is an interesting area that requires further analysis.

Products from the 3rd generation of GM technology, such as new materials and new energies, draw considerable attention towards Cluster 4 consumers. The consumers in Cluster 4 have a higher income and are more interested in non-food GM technologies. They will be the main supporters of GM industrial products, such as new medicines and new materials for biofuels. Nevertheless, the Chinese government should fully evaluate the attitudes of Cluster 4 consumers before plant molecular farming is carried out in China.

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[4] The recent list of agricultural GMOs applied labeling includes 17 products from five crops. They are soybean seeds, soybeans, soy flour, soy oil, soy meal; corn seeds, corn, corn oil, corn flour; rape seeds for planting, rape seed, rape seed oil, rape seed meal; cotton seeds for planting; tomato seeds, fresh tomatoes, and tomato sauce.

References

Baker, G.A., Burnham, T.A., 2001. Consumer response to genetically modified foods: market segment analysis and implications for producers and policy makers. Journal of Agricultural and Resource Economics 26 (2), 387–403.

Christophe, I., Bruhn, M., Roosen, J., 2008. Knowledge, attitudes towards and acceptability of genetic modification in Germany. Appetite 51, 58–68.

Curtis, Kynda R., McCluskey, Jill J., Wahl, T.I., 2004. Consumer acceptance of genetically modified food products in the developing world. AgBioForum 7, 70–75.

Fernandez-Cornejo, J., Caswell, M., 2006. The First Decade of Genetically Engineered Crops in the United States. Economic Research Service, USDA. Economic Information Bulletin Number 11, April 2006.

Gale, F., Lin, B.L., Tuan, F., 2002. Is biotechnology in China's future? In: Gale, F. (Ed.), China's Food and Agriculture: Issues for the 21st Century. Economic Research Service, USDA (AIB No. 775).

Gaskell, G., Allum, N., 2003. Europeans and biotechnology in 2002. Eurobarometer 58.0. DG research, European Commission.

Gaskell, G., Allum, N., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., Bardes, J., 2004. GM foods and the misperception of risk perception. Risk Analysis 24 (1), 185–194.

Gaskell, G., Stares, S., Allansdottir, A., Allum, N., Corchero, C., Fischler, C., Hampel, J., Jackson, J., Kronberger, N., Mejlgaard, N., Revuelta, G., Schreiner, C., Torgersen, H., Wagner, W., 2006. Europeans and Biotechnology in 2005: Patterns and Trends. A Report to the European Commission's Directorate-General for Research. <http://www.ec.europa.eu>.

Hair, J., Anderson, R.E., Tatham, R., Black, W.C., 1995. Multivariate Data Analysis, fourth ed. Prentice Hall, Englewood Cliffs, New Jersey.

Hallman, W.K., Hebden, W.C., Aquino, H.L., Cuite, C.L., Lang, J.T., 2003. Public Perceptions of Genetically Modified Foods: A National Study of American Knowledge and Opinion. Food Policy Institute, Rutgers, The State University of New Jersey, USA.

Hossain, F., Onyango, B., 2004. Product attributes and consumer acceptance of nutritionally enhanced genetically modified foods. International Journal of Consumer Studies 28 (3), 255–267.

Huang, J.K., Rozelle, S., Pray, C., Wang, Q.F., 2002a. Plant biotechnology in China. Science 295 (5555), 674–676.

Huang, J.K., Pray, C., Rozelle, S., 2002b. Enhancing the crops to feed the poor. Nature 418 (8), 678–684.

Huang, J.K., Qiu, H.G., Bai, J.F., Pray, C., 2006. Awareness, acceptance of and willingness to buy genetically modified foods in Urban China. Appetite 46, 144–151.

Huang, J.K., Wu, Y.H., Zhi, H.Y., Rozelle, S., 2008a. Small holder incomes, food safety and producing, and marketing China's fruit. Review of Agricultural Economics 30 (3), 469–479.

Huang, J.K., Zhang, D.L., Yang, J., Rozelle, S., Kalaitzandonakes, N., 2008b. Will the biosafety protocol hinder or protect the developing world: learning from China's experience. Food Policy 33, 1–12.

IFIC (International Food Information Council), 2004. Support for Food Biotechnology Stable Despite News on Unrelated Food Safety Issues. <http://ific.org/research/biotechres03.cfm>.

Kaye-Blake, W., O'Connell, A., Lamb, C., 2007. Potential market segments for genetically modified food: results from cluster analysis. Agribusiness 23 (4), 567–582.

Kornelis, M., de Jonge, J., Frewer, L.J., Dagevos, H., 2007. Consumer selection of food-safety information sources. Risk Analysis 27 (2), 327–335.

Li, Q., Curtis, K.R., McCluskey, J.J., Wahl, T.I., 2003. Consumer attitudes toward genetically modified foods in Beijing, China. AgBioForum 5 (4), 145–152. <http://www.agbioforum.org>.

Lin, William, Somwaru, Agapi, Tuan, Francis, Huang, Jikun, Bai, Junfei, 2006a. Consumers' willingness to pay for biotech foods in China: a contingent valuation approach. AgBioForum 9 (3), 166–179.

Lin, William, Somwaru, Agapi, Tuan, Francis, Huang, Jikun, Bai, Junfei, 2006b. Consumer attitudes toward biotech foods in China. Journal of International Food and Agribusiness Marketing 18 (1/2), 177–203.

Qiu, H., 2005. Consumers' Attitudes Towards Genetically Modified Foods in Urban China. Ph.D. Dissertation, Chinese Academy of Sciences.

Wolf, M.M., Bertolini, P., Parker-Garcia, J., 2004. A Comparison of Consumer Attitudes towards GM Food in Italy and the USA. In: Evenson, R.E., Santaniello, V. (Eds.), Consumer Acceptance of Genetically Modified Foods. CABI Publishing, UK, pp. 131–141.

Wu, K., Lu, Y., Feng, H., Jiang, Y., Zhao, J., 2008. Suppression of cotton bollworm in multiple crops in China in areas with Bt toxin-containing cotton. Science 321 (5896), 1676–1678.

Zhang, X., Dagevos, H., He, Y., van der Lans, I., Zhai, F., 2008. Consumption and corpulence in China. A consumer segmentation study based on the food perspective. Food Policy 33, 37–47.

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