Consumers’ preferences for micronutrient strategies in China. A comparison between folic acid supplementation and folate biofortification.

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Abstract

Despite the successful efforts to reduce the burden of micronutrient malnutrition in China, folate deficiency or a chronic lack of vitamin B_{9} still largely affects the poor, rural populations, and women of childbearing age in particular. Although supplementation is currently the main micronutrient strategy to tackle folate deficiency in China, folate biofortification, i.e. the enhancement of folate levels in staple crops, has been recently proposed as a valuable alternative to the current micronutrient strategies.

Through experimental auctions in a folate deficient region (n=126), this paper determines and compares consumers’ willingness-to-pay for two folate strategies. By using rice as the food vehicle for folate enhancement, GM or non-GM folate biofortified rice was auctioned together with non-GM rice that is sold together with free folic acid pills. Furthermore, while an ex-post negative valuation approach was used to determine the consistency in zero bidding, a product preference question was used to further validate the obtained bids. In general, a preference for folate biofortification is observed, regardless of the applied breeding technology. Nevertheless, folic acid supplementation is more popular in the group of female students. Zero bidding behavior as well as the product preference question at the end of the auctions further confirm these findings. Regarding the latter, the targeted sample, the timing of the auction, the intention to eat GM food and the responsibility for rice purchases are considered key determinants. A targeted micronutrient approach is proposed to address folate deficiency.

Introduction

Controlling micronutrient malnutrition is a major public health priority in China. Since the 1990s, China experienced the most dramatic declines in the share of undernourished people and is, compared to other Asian countries, likely to achieve the UN 2015 target on nutrition (UN, 2004; UNICEF, 2006). Nevertheless, because the most important staple foods such as wheat and rice are poor sources of folate (vitamin B_{9}), folate deficiency (< 400 μg, per day) remains a serious health problem for children and women of childbearing age in rural areas of China. It is estimated that about 258 million Chinese people suffer from folate deficiency (De Steur et al., 2010a). As a consequence, each year approximately 18,000 babies are born with a neural-tube defect (NTD; e.g. spina bifida), i.e. about 9% of the global prevalence.

With respect to Shanxi Province, one of China’s poorest rural regions, the situation is even more problematic. Each day about 6.5 births are affected by an NTD, leading to the world’s highest rate of birth defects (Dai et al., 2002). Like any other micronutrient deficiency, current policy interventions to reduce folate deficiency are mainly built upon pharmaceutical supplementation (folic acid pills) or industrial fortification (folic acid fortified staple crops). Although China is primarily targeted at folic acid supplementation, past supplementation programs were known to have a short term effect (Li and Hao, 2008), by which the use of folic acid pills is currently low (Zhao et al., 2009). In Shanxi Province, for example, only 7.7% of women of childbearing age ever used folic acid pills (Zhang et al., 2006), while 44% of pregnant women do not achieve the recommended daily dose of folate (Ren et al., 2006). On the other hand, folic acid fortification of China’s two most important staple crops is expected to pose practical, technical and financial difficulties, partly due to the highly segmented rice and wheat milling sectors in China (ADB, 2004; Wailis and Lee, 2008).

To address folate deficiency when such folic acid based strategies are less feasible or effective, genetic engineering has been recently applied to develop staple crops with a higher folate content, i.e. GM folate biofortification (Blancquaert et al., 2010). Folate biofortified rice
(FBR), currently the most advanced folate enriched GM crop (Storozhenko et al., 2007; Bekaert et al., 2008), is expected to be a valuable and highly cost-effective strategy to reduce the health burden of folate deficiency in China and its regions (De Steur et al., 2010a; De Steur et al., 2012).

From a marketing point of view, knowing the needs and potential reactions of the targeted populations, contributes to a successful implementation of health interventions, especially in the case of controversial products, such as GM foods. As Musgrove and Fox-Rushby (2006) stated: “The effectiveness of an intervention and, therefore, the degree to which it deserves priority depend on how far it is culturally appropriate or acceptable for the population it is intended to benefit” (p. 227). Although previous consumer studies showed that Chinese people are generally favorable of GM food (Ho et al., 2006; Huang et al., 2006; Lin et al., 2006; Liu, 2009), especially if health benefits are attached (Li et al., 2002; De Steur et al., 2010b; Zhang et al., 2010), it remains to be proven if they would be as enthusiastic for GM biofortified crops when non-GM alternatives are available. In other words, to assess the true potential of GM biofortification it is key to analyze consumer preferences for different micronutritional health interventions simultaneously.

Therefore, this paper aims to investigate and compare consumers’ willingness-to-pay (WTP) and preference for folate biofortification (GM) versus folic acid supplements (non-GM). Therefore, an economic valuation study is conducted in Shanxi Province, a poor, developing region that accounts for the largest burden of folate deficiency in China (De Steur et al., 2010a). Due to the large body of evidence on the influence of maternal folate deficiency on the risk of having a baby with an NTD (MRC Vitamin Study Research Group, 1991; Lumley et al., 2001), only women of childbearing age were targeted in this study.

Methodology

In order to determine and compare consumers’ WTP for these two folate products, seven experimental auctions were organized with 126 female consumers from Taigu, Shanxi Province, of which 60 students participated at school and 66 non-students were recruited near the market place. Both auctions were held in a laboratory setting. Using experimental methods to elicit valuations for GM foods with health benefits is relatively new, with Rousu et al. (2005) being the first to explore this area. With respect to GM biofortification, previous auction studies focused solely on provitamin A enriched products, such as maize in Kenya (De Groote et al., 2011), cassava in Brazil (Gonzalez et al., 2009), or Golden Rice in the Philippines (Depositario et al., 2009) and the United States (Lusk, 2003).

The novelty of applying this valuation method to biofortification not only lies in the targeted sample, i.e. poor, rural, female rice consumers from a high-risk region, but also refers to the inclusion of a non-GM substitute in auction research for GM foods. China’s main staple crop, rice, was selected to compare two key folate interventions, folate biofortification and folic acid supplementation. Therefore, two rice products were simultaneously auctioned: rice enriched with folate (FBR) and rice sold together with 7 folic acid supplements (FAR). In this way, the most common micronutrient strategy to increase folate intake levels in China, as well as a potential alternative strategy were brought into the auction. Hence, we address the need to include substitutes as an auction design effect in GM food auctions, as acknowledged by Kassardjian et al. (2005) and Corrigan et al. (2005; 2009).

Experimental auction design

The auction design follows the key steps in food auctions: briefing, training and practice, bidding rounds and debriefing. The value elicitation method is based on the 2\textsuperscript{nd} price (Vickrey) auction mechanism, by which the highest bidder of the binding auction round is selected as the buyer and, thus, has to purchase the binding auctioned product at the amount of the 2\textsuperscript{nd}
highest bidder. An endowment bidding procedure is applied, which requires people to bid the amount they are prepared to pay to exchange an initial given product, i.e. regular rice (5.2 ¥ per kg), with the novel, auctioned product, i.e. FBR or FAR. The actual auctions consist of three subsequent bidding rounds, by which information is provided regarding (1) the folate content, (2) the folate benefits and (3) the applied technology. Table 1 summarizes the different information treatments per auctioned product. Except for the last bidding round, the sheets are more or less similar for both products. All participants received the same amount of information.

Table 1 Information sheets per auction round and auctioned product

<table>
<thead>
<tr>
<th>Folate enriched rice bag (Product 821)</th>
<th>Rice bag + 7 folic acid pills (Product 753)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auction round 1: Folate content</strong></td>
<td></td>
</tr>
<tr>
<td>- 1 kilogram rice with high folate content</td>
<td>- 1 kilogram regular rice sold together with 7 folate pills</td>
</tr>
<tr>
<td>- Same taste, appearance, … as regular rice</td>
<td></td>
</tr>
<tr>
<td>- 40 times more folate than your bag</td>
<td>- 40 times more folate than your bag</td>
</tr>
<tr>
<td>- By eating this rice each day, you eat enough folate intake level per day</td>
<td>- By taking one pill each day, you achieve the recommended folate intake level per day</td>
</tr>
</tbody>
</table>

**Auction round 2: Folate benefits**

Consuming this product is very healthy, because it:
- Pregnant women: drastically reduces the risk of having a baby with a birth defect
- All people: reduces the risk of having a still birth
- reduces the risk of different types of cancers and heart and cardiovascular diseases
- reduces the risk of Alzheimer
- reduces the risk of Anemia (lack of oxygen in the blood)
- improves the overall resistance to diseases

Consuming this product is very healthy, because it:
- Pregnant women: drastically reduces the risk of having a baby with a birth defect
- All people: reduces the risk of having a still birth
- reduces the risk of different types of cancers and heart and cardiovascular diseases
- reduces the risk of Alzheimer
- reduces the risk of Anemia (lack of oxygen in the blood)
- improves the overall resistance to diseases

**Auction round 3: GM technology**

- This product is made using genetic modification (GM)
- This product is not made using genetic modification (GM)

Note: The information sheets are translated from Chinese. 1 kg (2 Jín) bag of regular rice of 5.2 Yuan. 1 Yuan is approximately $0.15.

A regular rice bag of 1 kg contains about 80 µg of folate (USDA, 2008), while an FBR bag of the same size contains approximately 3 000 µg (Storożenko et al., 2007; De Steur et al., 2010a). To be able to compare FBR with FAR, we attached 7 folic acid pills to the bag (400 µg per pill). Based on the average rice consumption in Shanxi Province, estimated at 133 g rice (CNGOIC, 2009), one could achieve the recommended folate intake for a week, either by consuming each day folate enriched rice or taking one folate pill per day.

Bekaert et al. (2008)
Molloy and Scott (2001), Bailey et al. (2003), Geisel (2003) and Blancquaert (2010)
A general GM food definition is mentioned, derived from key reports (FAO, 2004; Lusk et al., 2004; HGP, 2008).

Because the participants receive GM information latest, three key product comparisons can be made (see Figure 1). First of all, based on the 2nd round bids, i.e. when the participants are aware of the folate content and the potential health benefits of both products, WTP values for FBR and FAR both refer to non-GM strategies to improve folate intake (‘non-GM comparison’). This is when the folate content of rice would be enhanced through conventional breeding techniques. In the 3rd round, the focus shifts towards the GM nature of FBR. Therefore, the ‘GM comparison’ reflects bidding behavior when GM FBR and (non-GM) FAR are auctioned together. In other words, it measures the impact of consumers’ awareness of the GM technology in FBR on both folate products. Third, the difference between WTP for FBR before and after the 3rd round reveals the impact of the applied breeding technology, i.e. whether FBR is based on conventional or GM breeding techniques (‘FBR comparison’). It is important to note that the latter is the result of juxtaposing two FBR bids from subsequent
information rounds, while the former two comparisons represent bid differences between two folate products that are auctioned in the same round.

Figure 1 Comparison of WTP values for FBR (non-GM, GM) and FAR (non-GM) based on the three information rounds
FAR, folic acid pills + rice; FBR, folate biofortified rice; GM, genetically modified.
Remark: As participants did not receive information regarding the applied technology in the 1st and 2nd round, their FBR bids reflect WTP values for the non-GM product. Folate products in bold are part of a product comparison. Due to the high correlation between bids of the 1st and 2nd round, only the latter values are used in the analysis, as they are based on additional information.

At the end of the bidding rounds, the participants were asked to state their preference when both folate products would be available in the market. This consumers’ preference reflects an ‘informed’ choice and consists of three categories: FBR preference, FAR preference, no preference. A similar approach is also used in contingent valuation methods with other biofortified products (Corrigan et al., 2009). Because the development of a non-GM FBR will be less likely to be as successful as when GM techniques are used (Blancquaert et al., 2010), the product preference was only measured after the last round.

Given the controversy associated with the use of GM technology in foods, the third information round is expected to reveal the most reluctant bidding behavior. Therefore, particular attention will be paid to zero bidding behavior in the last round. Through an additional bidding slip, zero bidders of FBR or FAR were asked whether they would be interested to buy the folate-rich products at a value below the price of a regular product. Stated differently, the zero bidders in the 3rd round had the opportunity to bid a negative value.

Contrary to the general bidding rule in WTP studies, i.e. values truncated at zero, some authors allowed negative bids in their Vickrey auction to reduce an implicit quality bias of the endowed product. This approach is relatively new in food auction literature (Dickinson and Bailey, 2002; Parkhurst et al., 2004; Hobbs et al., 2006; Chern and Chang, 2009; Wang and McCluskey, 2010) and is particularly relevant when auctioning controversial goods (Parkhurst et al., 2004), such as GM food products. Here, our approach differs from Parkhurst et al. (2004) who incorporated negative values in the bidding procedure itself. Introducing negative valuations as an ex-post bidding procedure, makes it possible to explore the need for an incentive (discount) to purchase folate products and avoids large negative bids that were submitted in order to increase the monetary benefits. Even though negative values are not incorporated in the main bidding rounds and are, strictly speaking, hypothetical, they help to gain insight in the motives behind zero bidding behavior.
Data analysis

Data were entered using SPSS, version 19. Statistical analysis mainly consists of Wilcoxon signed rank tests (product comparison) and multinomial logistic regression (product preference). Because the WTP values were not normally distributed, but left-skewed, the non-parametric Wilcoxon (matched-pairs) signed-rank test was required to test the difference between two bidding rounds, i.e. two WTP values. This test is similar to the sign test, but the former is assumed to be more powerful (Roosen et al., 1998). Multinomial logistic regression was employed to explore the determinants of product preference through a combination of binary logistic regressions.

Results
Sample descriptives

The key characteristics of the sample are presented in Table 1. The variables TARGET and TIMING refer to the experimental design, as described in the methodology section. The socio-demographic profile is closely related to the objectives of the experiment, i.e. measuring consumers’ WTP for micronutrient strategies in a malnourished region of China. All participants are women of childbearing age, on average 30 years old and mainly living in rural areas. Nearly half of the sample is responsible for the rice purchases at home, while 60 % is involved in farming activities within their household. As for the intention to become pregnant in the future, the group is more or less equally divided. Only one women was known to be pregnant during the experiment. Regardless of the correctness of the intake, 17.5 % of our sample only took folic acid once, which is higher (but still low) than previous findings in Shanxi Province, e.g. 7.7 % (Zhang et al., 2006), 10.2 % (Li et al., 2007), 12.0 (Zeng et al., 2011) and 14.7-15.3 % (Ren et al., 2006; Ren et al., 2007). The limited success of folic acid supplements, as well as the high familiarity with NTD cases clearly underlines the need to address folate deficiency in this Shanxi Province, in line with folate status (e.g. Ren et al., 2006) and NTD prevalence studies in high-risk region (e.g. Gu et al., 2007).

Despite the high subjective knowledge of GM food, with 64.3 % of the sample stating to know what GM food is, the objective knowledge score is relatively lower (50.1 %). The lack of GM knowledge has been pointed out in other Chinese studies (Ho et al., 2006; Huang et al., 2006; Lin et al., 2006) and confirms the discrepancy between subjective and objective knowledge (Li et al., 2002). Nevertheless, the intention to consume GM food in this study, with 81.7 % of the total sample not being reluctant, supports the optimistic view of Shanxi consumers in 2008 (De Steur et al., 2010b).
Table 1 Variable descriptions of the experiment sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Timing</th>
<th>Mean</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auction design characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TARGET</td>
<td>Targeted sample (0 = school sample; students of childbearing age; 1 = market sample; women of childbearing age)</td>
<td>/</td>
<td>0.52</td>
<td>0.50</td>
</tr>
<tr>
<td>TIMING</td>
<td>Timing of the auction (0 = morning; 1 = afternoon)</td>
<td>/</td>
<td>0.75</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Socio-demographic variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>Age of the participant (years)</td>
<td>At start</td>
<td>30.41</td>
<td>11.67</td>
</tr>
<tr>
<td>RICEPURCH</td>
<td>Responsible for the rice purchases in the household (0 = no; 1 = yes)</td>
<td>At start</td>
<td>0.48</td>
<td>0.50</td>
</tr>
<tr>
<td>FARMER</td>
<td>Involved in farming activities (0 = not a farmer; 1 = farmer)</td>
<td>At start</td>
<td>0.59</td>
<td>0.49</td>
</tr>
<tr>
<td>FUTPRG</td>
<td>Intention to become pregnant in the future (0 = no; 1 = yes)</td>
<td>At start</td>
<td>0.52</td>
<td>0.50</td>
</tr>
<tr>
<td>RESIDENCE</td>
<td>Residence (0 = urban; 1 = rural)</td>
<td>At start</td>
<td>0.83</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Variables related to folate/folic acid</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLICUSE</td>
<td>Ever used folic acid supplements (0 = no; 1 = yes)</td>
<td>Before round 2</td>
<td>0.17</td>
<td>0.38</td>
</tr>
<tr>
<td>NTDKNOW</td>
<td>Knowledge of a women who delivered a baby with an NTD (0 = no; 1 = yes)</td>
<td>Before round 2</td>
<td>0.41</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>Variables related to GM food</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBJKNOW</td>
<td>Subjective/perceived knowledge of GM food (0 = no; 1 = yes)</td>
<td>Before round 3</td>
<td>0.66</td>
<td>0.47</td>
</tr>
<tr>
<td>OBJKNOW</td>
<td>Objective knowledge of GM food (% of correct statements)</td>
<td>Before round 3</td>
<td>0.50</td>
<td>0.27</td>
</tr>
<tr>
<td>INTENTION</td>
<td>If GM food would be available for consumption, I would eat it (1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree)</td>
<td>Before round 3</td>
<td>3.08</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Dependent variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREFERENCE</td>
<td>If you could buy the two auctioned products in the supermarket, which one would you buy? (0 = FBR, 1 = FAR; 2 = no preference)</td>
<td>After round 3</td>
<td>0.52</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Remark: The third column refers to the timing of the self-administered survey question. The auction design characteristics are not included in the survey.

Comparison of micronutrient strategies

Table 2 gives an overview of the average bids and the share of zero bidders for each pair of auctioned folate products. Thereby, the results are split up according to the targeted sample of the experimental auctions. Somewhat surprising, the Wilcoxon test reveals that WTP values for FBR are significantly higher than for FAR, even when FBR is associated with GM technology. In general, WTP values for FBR vary between ¥ 1.76 (GM) and ¥ 1.90 (non-GM), compared to ¥ 0.99 for FAR. Furthermore, the participants do not bid significantly different for the two folate biofortified products, except in the group of students (school setting), where the GM nature of FBR is negatively valued. In other words, the applied technology of FBR generally does not affect its valuation.

A similar pattern is observed regarding zero bidding behavior, namely large differences between the two non-GM folate products, regardless of the observed sample, and sample
differences in the GM and FBR comparison. In the school sample, for example, zero bidding for GM FBR is substantially more present than in the general sample.

Table 2 Comparison of WTP values between non-GM/GM FBR and non-FAR, mean bids (¥) and share of zero bids, bid differences, per targeted sample and product comparison

<table>
<thead>
<tr>
<th></th>
<th>FBR (non-GM)</th>
<th>FBR (GM)</th>
<th>FAR (non-GM)</th>
<th>FAR (GM)</th>
<th>FBR (non-GM)</th>
<th>FBR (GM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School sample n = 60</td>
<td>Mean bid</td>
<td>1.62</td>
<td>1.35</td>
<td>0.93</td>
<td>1.62</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>(st.dev.)</td>
<td>(1.17)</td>
<td>(1.32)</td>
<td>(1.27)</td>
<td>(1.17)</td>
<td>(1.32)</td>
</tr>
<tr>
<td>Δ Mean bid</td>
<td>0.82</td>
<td>0.42</td>
<td>-3.55**</td>
<td></td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Wilcoxon Test</td>
<td>-5.51***</td>
<td></td>
<td></td>
<td></td>
<td>-3.32***</td>
<td></td>
</tr>
<tr>
<td>Zero bids (%)</td>
<td>3.3</td>
<td>18.3</td>
<td></td>
<td></td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Δ zero bids (%)</td>
<td>-27.6</td>
<td>-6.7</td>
<td></td>
<td></td>
<td>-15.0</td>
<td></td>
</tr>
<tr>
<td>Market sample n = 66</td>
<td>Mean bid</td>
<td>2.16</td>
<td>2.14</td>
<td>0.94</td>
<td>2.16</td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>(st.dev.)</td>
<td>(1.96)</td>
<td>(1.87)</td>
<td>(1.35)</td>
<td>(1.96)</td>
<td>(1.87)</td>
</tr>
<tr>
<td>Δ Mean bid</td>
<td>0.99</td>
<td>1.20</td>
<td></td>
<td></td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Wilcoxon Test</td>
<td>-4.99***</td>
<td></td>
<td></td>
<td></td>
<td>-1.58</td>
<td></td>
</tr>
<tr>
<td>Zero bids (%)</td>
<td>6.1</td>
<td>12.1</td>
<td></td>
<td></td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td>Δ zero bids (%)</td>
<td>-22.7</td>
<td>-28.8</td>
<td></td>
<td></td>
<td>-6.0</td>
<td></td>
</tr>
<tr>
<td>Total n = 126</td>
<td>Mean bid</td>
<td>1.90</td>
<td>1.76</td>
<td>0.94</td>
<td>1.90</td>
<td>1.76</td>
</tr>
<tr>
<td></td>
<td>(st.dev.)</td>
<td>(1.65)</td>
<td>(1.67)</td>
<td>(1.31)</td>
<td>(1.65)</td>
<td>(1.67)</td>
</tr>
<tr>
<td>Δ Mean bid</td>
<td>0.91</td>
<td>0.82</td>
<td></td>
<td></td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Wilcoxon Test</td>
<td>-7.38***</td>
<td></td>
<td></td>
<td></td>
<td>-0.87</td>
<td></td>
</tr>
<tr>
<td>Zero bids (%)</td>
<td>4.8</td>
<td>15.1</td>
<td></td>
<td></td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Δ zero bids (%)</td>
<td>-24.6</td>
<td>-18.2</td>
<td></td>
<td></td>
<td>-10.3</td>
<td></td>
</tr>
</tbody>
</table>

FAR, folic acid pills + rice; FBR, folate biofortified rice; GM, genetically modified.

Remark: 1 ¥ ~ 0.15 USD. The symbol *** indicates p<0.001.

Product preference

With respect to the product preference that is measured after the 3rd auction round, the results show that 66.7 % is favorable of the former, while only 15.1 % would buy the latter and 18.3 % is indifferent. Looking at the two samples (target groups), two conclusions can be made. Compared to the general group of women of childbearing age (market sample), significantly more students are indifferent (23.3 % versus 13.6 %) or prefer the non-GM folic acid supplements (21.7 % versus 9.1 %), but is less favorable of buying FBR (55.0 % versus 77.3 %)(χ²=7.25, p=0.03). Notwithstanding the students’ preference for FAR, these results generally confirm the unattractiveness to buy FAR. As such, FBR might become a highly accepted alternative strategy to tackle folate deficiency in particular populations.

Through multinomial logistic regression analysis, the determinants of product preference were examined. As shown in Table 3, our model explains 35.6 % of the variance. The targeted sample (school versus market), the timing of the auction, consumers’ intention to eat GM food and being responsible for the rice purchases are considered as key factors. The effect of these variables can be interpreted by the parameter estimates of the multinomial logistic regression. First, there is a targeted sample effect. While the majority of participants in the non-student auctions are in favor of the folate enriched GM rice, the preference of the female students is more oriented towards FAR. It is important to note that this does not mean that students do not want to buy FBR, but that they generally choose FAR over FBR, regardless of their value for FBR. Furthermore, students are more likely to prefer FAR rather than to take an indifferent position. Second, the participants in the morning sessions are more likely to be indifferent, while participation in the afternoon increases the likelihood of being in favor of FAR. Third, consumers in charge of the rice purchases have a lower probability to be indifferent. Finally, as expected, the odds to belong in the group of
consumers that favor FBR is positively influenced by an intention to consume GM food. A similar positive effect is found in other GM food studies (Bredahl et al., 1998; Verdurme et al., 2003; Lin et al., 2006; Costa-Font et al., 2008). Despite its insignificance, NTDKNOW also seem to drive consumers towards FBR.

The explained variance increases to 45.6 % when the bids of the 2nd round (non-GM comparison) are added to the model. This is mainly due to the correlation between the bids in round 2 and round 3.

Table 3 Significant determinants of the consumers’ preference for folate products, by Multinomial Logistic Regression, likelihood ratio tests and parameter estimates per binary logistic comparison

<table>
<thead>
<tr>
<th>Preference</th>
<th>Likelihood ratio tests</th>
<th>GM FBR versus FARb</th>
<th>GM FBR versus no preferenceb</th>
<th>GM FBR versus no preferenceb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable (dummya)</td>
<td>χ²</td>
<td>p</td>
<td>B</td>
<td>p</td>
</tr>
<tr>
<td>AGE</td>
<td>0.46</td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RICEPURCH (no)</td>
<td>6.92</td>
<td>0.03</td>
<td>2.39</td>
<td>0.09</td>
</tr>
<tr>
<td>FARMER</td>
<td>2.06</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FUTPREG</td>
<td>1.51</td>
<td>0.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESIDENCE</td>
<td>0.32</td>
<td>0.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLICUSE</td>
<td>1.09</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NTDKNOW (no)</td>
<td>4.38</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBJKNOW</td>
<td>1.24</td>
<td>0.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OBJJKNOW</td>
<td>1.62</td>
<td>0.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTENTION</td>
<td>7.47</td>
<td>0.02</td>
<td>0.88</td>
<td>0.01</td>
</tr>
<tr>
<td>TARGET (school)</td>
<td>7.31</td>
<td>0.03</td>
<td>-3.10</td>
<td>0.05</td>
</tr>
<tr>
<td>TIMING (morning)</td>
<td>7.10</td>
<td>0.03</td>
<td>-2.43</td>
<td>0.01</td>
</tr>
<tr>
<td>Model</td>
<td>43.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nagelkerke R²</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remark: The dependent variable, consumer preference, consists of three categories: FBR preference, FAR preference and indifference. To compare all groups of the dependent variable, three binary logistic regressions are presented. Bold indicates a significant effect.
a The parameter estimates of the dummy variables refer to a specific category, expressed in parentheses; b Reference category.

Zero bidding behavior and negative valuations

Figure 2 juxtaposes the total number of zero bidders and “new zero bidders”. The latter is defined as participants who start to bid zero after they received new information. The total number of zero bidders is the sum of these new zero bidders and those who did not change their zero bid from the previous round (see also Table 2).

In the 1st round the number of new zero bidders equals the total number of zero bids. Zero bids in the non-GM product comparison (2nd round) most likely refer to consumers’ reluctance of the information about the folate content (1st round) and the folate benefits (2nd round). Reasons for zero bidding in this comparison round might be related to the concerns regarding the high folate content or the inconvenience of taking pills (daily).

As expected, most participants turn their positive FBR bid into a zero bid upon learning that GM technology is used (“GM comparison”). Surprisingly, the number of FAR zero bids also increases upon receiving this information. Together with the large discrepancy between new zero bidders in the ‘FBR comparison’, one can conclude that non-GM FBR provokes the least negative reactions, but the evaluation of GM FBR is not as negative as one might have expected. Stated differently, the absence of a reduction in zero bidding behavior towards non-GM FAR underlines consumers’ general preference for FBR.
The additional negative valuation approach somewhat nuances the aforementioned figures regarding the ‘GM comparison’. Out of the 44 FBR zero bidders in the third round, only 15.8 % are consistent in their reluctance and are not willing to buy FBR, even if there would be a discount. The other participants claim to accept FBR if it would be cheaper, i.e. between ¥ 0.2 to ¥ 2.0. These figures are comparable with another Chinese GM rice study (Li et al., 2002). In the case of the non-GM FAR, only 7.3 % of 42 zero bidders are not interested in a discount. This demonstrates that a large part of FAR zero bidders considers the value of the additional free folic acid supplements not higher than regular rice, but will not be averse of buying FAR when the price would be more competitive, i.e. on average ¥ 0.57 lower. Comparison of both products shows that awareness of the GM technology causes more people to maintain their initial zero bids for FBR, but not as much as would have been expected.

Discussion

This paper analyzes consumers’ WTP and product preference for two micronutritional health strategies: biofortification, based on transgenic or conventional breeding techniques, and vitamin supplementation. As such, three key comparisons of WTP values for both products were examined: (1) non-GM FBR versus FAR, (2) GM FBR versus FAR and (3) non-GM FBR versus GM FBR. Based on 2\textsuperscript{nd} price auctions with 126 female rice consumers from a Chinese folate deficient region, the results show a general preference for FBR over FAR, even in the case of GM FBR. Stated differently, they are more willing to pay for a rice bag where the level folate is enhanced, regardless of the applied technology, than for a similar rice bag where the same amount of folate is supplied through free folic acid pills. Compared to the compliance of taking pills, the convenience of folate incorporated in FBR seems to outweigh the absence of a controversial technology in FAR. Differences in zero bidding behavior between the two folate products generally supports these findings. However, the number of ‘new zero bidders’ revealed that opposition towards GM FBR may drive a small share of consumer towards the alternative non-GM product. This study also sheds a novel light on zero bidding behavior for controversial goods through the elicitation of negative values as an ex-post survey question. Only a small part of the zero bidders consistently refused to buy GM FBR when having the option to submit a negative bid. The unattractiveness of FAR is also observed in the data on consumers’ choice between

![Figure 2 Number of zero bidders and new zero bidders regarding FBR and FAR, per product comparison.](image)
folate products. This leads to the conclusion that GM foods with health benefits are not as controversial as one might have expected. Even when non-GM alternatives are offered, there is a potential for folate biofortification as an alternative micronutritional strategy in China.

Together with the limited access to folic acid in rural areas (Li and Hao, 2008), the poor knowledge of the correct time of intake (Ren et al., 2006), the low awareness of the need for folate (Zeng et al., 2011) and the large number of unintended pregnancies in China (Durkin et al., 2006), the novel insights on the low attractiveness of FAR provide an additional argument for the limited success of past folic acid supplementation programs and the current low use of folic acid pills. Given the differences between the school and market sample, by which the unattractiveness of FAR is less pronounced in the group of students (school sample), a folic acid supplementation intervention that is targeted at the future generation of mothers, might be more appropriate and effective on the long term. Although the general group of women of childbearing age (market sample) appears to be less relevant from a birth defect control point of view – due to China’s one-child policy - they are mainly in charge of the rice purchases in their household. As these persons are better placed to choose one of the two folate products, their general preference for FBR should be also taken into account. Not surprisingly, their initial intention to consume GM food is found to be the key determinant that influences their decision in favor of FBR.

From a purely economic perspective, the WTP values could be used, and juxtaposed with the implementation costs of these micronutritional strategies, in order to decide whether it is beneficial and commercially viable to adopt them or to set a price level, e.g. based on a premium (i.e. WTP value) that ensures a sufficient market share (Breidert et al., 2006; Lusk and Norwood, 2006). Despite the importance of consumers’ valuation for price-setting (Lusk and Hudson, 2004), it is certainly not the only key factor that affects pricing decision (Monroe and Cox, 2001). Even though the study revealed that poor consumers are prepared to pay for FBR, the ability-to-pay might be an important constraint of the empirical validity of the results, as shown in valuation studies on health care options in poor populations (Donaldson, 1999). Poor Shanxi rice consumers may not be able to pay the high premium they have stated in the auctions. Therefore, the high WTP values should be interpreted as consumers’ preferences of FBR or FAR over regular rice.

In this way, the preference question after the final auction round appears to offer not much value to this study. Indeed, in nearly all cases the product with the highest value is preferred. However, this is interesting because it shows that the submitted bids represent the economic value a consumer attaches to the auctioned product, rather than their evaluation of the (preferred) cost of this product. In this way, evaluating consumers’ preference at the end of the auctions can be considered an additional tool to validate the bids and to examine whether consumers actually understand the purpose of bidding. In line with Lusk (2007), a participant would have probably indicated a preference for the product with the lowest value when she would have expected that her response could have influenced the future price of the auctioned good(s).

By comparing consumers’ valuations for different folate product comparisons, the strong preferences for FBR could be incorporated in the decision regarding its incorporation in a (combined) micronutritional strategy. As Pearce and Özdemiroglu (2002, p. 22) stated: “Economic values expressed in money terms, [...] will reflect people’s preferences and can thus be used as weights to inform any policy analysis or decision process”. Gaining insight in these preferences makes it possible to benchmark different micronutritional strategies, predict the impact of information about the applied technology, develop activities to adequately address the target population and, thus, increase its success rate in areas where the need is the highest. If both FBR and FAR will be part of a national health policy program, it will be a challenge to simultaneously attract farmers, who seek to make profits out of the added value of FBR, poor consumers, who will have different rice varieties at their disposal.
or who need to be continuously motivated and informed to take FAR (correctly), and other stakeholders, who will need to be involved to commercialize, distribute and promote FBR and FAR, while taking into account the costs implications. Nevertheless, as FBR is still in a development phase, the aforementioned results should be considered as an ex-ante evaluation of folate strategies.

With respect to future research, it is important to note that this study refers to a specific context. First of all, using rice to compare folate biofortification and folic acid supplementation implies that our conclusions refer to rice based folate interventions. Second, the novelty of conducting auctions with key target audiences in micronutrient deficient regions might hamper the external validity, e.g. whether the results are valid for all Chinese populations. Third, only two folate strategies are addressed in the experimental auctions. The reason to exclude folic acid fortified rice was mainly because the target group is expected to have difficulties in understanding the difference with FBR. Although there is a clear difference between natural folate and synthetic folic acid, also in terms of their (side-)effects (Smith et al., 2008), this study emphasized the use of GM technology as the key attribute that distinguishes GM biofortification from supplementation. Future research might focus on how differences between folate and folic acid could affect acceptance and preference. Finally, more research is needed to examine the reasons behind the bid differences between micronutritional strategies. One option is to bring in psychometric tools, like a thought-listening exercise, where participants write down their thoughts when bidding (Jaeger and Harker, 2005; Kassardjian et al., 2005).

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