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Consumer Acceptance of Biofortified Iron Beans in Rural Rwanda: Experimental Evidence

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ABSTRACT

Iron deficiency among children and women of child-bearing age is a public health problem in many developing countries. Iron-biofortified varieties of commonly consumed staple crops have the potential to contribute to the daily iron requirements in diets. This paper examines consumer acceptance and willingness to pay (WTP) for two iron bean varieties in Rwanda: red iron bean (RIB) and white iron bean (WIB). Using the Becker-DeGroot-Marshak mechanism, the paper investigates the effect of (1) nutrition information; (2) informa tion frame (i.e., information emphasizing loss or negative consequences of not having enough iron in diets versus information emphasizing gains or benefits of having enough iron in diets); and, (3) the frequency of providing the information on consumer WTP for iron bean varieties. Econometric models are used that take into account several issues, such as social interaction, non-payment effect, and home inventory of beans.

Results indicate that in the absence of information about the nutritional benefits of the two iron bean varieties, consumers are willing to pay a large premium for the RIB variety, but not for the WIB variety, relative to the local variety. The nutrition information provided has a significantly positive effect on the premium for each of the iron bean varieties. Results also indicate that the effects of how the information is framed (i.e., loss versus gain messaging) on this premium are not statistically significant. However, providing the nutrition information three times versus once significantly increases consumer demand for the WIB variety. These findings could inform the design of efficient delivery and marketing strategies for iron bean varieties in Rwanda.

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CONTENTS

I. INTRODUCTION

Micronutrient malnutrition, also known as hidden hunger, is a serious public health problem in Rwanda. Thirty eight percent of children under 5 years of age and 17 percent of women of childbearing age suffer from anemia (Demographic Health Survey [DHS] 2010), about 50 percent of which is caused by iron deficiency (de Benoist et al. 2008). There are no iron supplementation programs for infants and young children, and according to the most recent DHS (2010), only 1 percent of women took iron supplements during their last pregnancy. Iron fortification of commonly consumed food vehicles is also absent in Rwanda.

Rwandans have the highest per capita bean consumption in the world (CIAT 2004), at an estimated 164 grams (g)/day (Ferris 2002). According to the latest National Agricultural Survey (NAS 2008), on average, Rwandan households eat beans 5 days a week. In an average Rwandan diet, beans provide 32 percent of calorie intake and as high as 65 percent of protein intake, whereas animal-source foods provide only 4 percent of protein intake (CIAT 2004). Moreover, almost all (97 percent) rural households in Rwanda are bean producers (Asare-Marfo et al. 2011). The majority of rural households' bean consumption comes from their own production (79–88 percent, depending on the season), while the remaining beans are purchased from the market (NAS 2008).

Given Rwandan households' high levels of bean consumption, production, and reliance on their own production to meet their bean needs, introduction of conventionally bred iron biofortified beans could be an effective and targeted public health intervention to alleviate iron deficiency in the country. In addition, according to the Biofortification Priority Index, among 127 countries in Africa, Asia, and Latin America and the Caribbean, Rwanda ranks as the number one country for the introduction of iron bean varieties (Asare-Marfo et al. 2013). Recent efficacy studies conducted under clinical randomized controlled trials have successfully demonstrated that regular consumption of iron beans improves the iron status of school-age children and young women (Haas et al. 2011; Luna et al. 2012).

The success of introducing iron bean varieties depends on whether they are accepted and consumed by the target populations. First, by using an incentive-compatible preference-elicitation mechanism, this paper attempts to measure consumers' willingness to pay (WTP) for iron bean varieties and estimate the magnitude of premium or discount relative to the local variety. Second, it investigates the effect of nutrition information on consumer WTP. Recent studies have shown that nutrition information is important in driving consumer acceptance of biofortified foods in Africa (Chowdury et al. 2011; De Groote et al. 2011; Meenakshi et al. 2012; Banerji et al. 2013; Oparinde et al. 2014). This paper adds to this literature by investigating not just the effect of the information on acceptance, but also the effects of how the information is framed (message emphasizing loss or negative consequences versus message emphasizing gain or benefits) and how frequently the information is conveyed.

An extensive literature on loss aversion shows that consumers' willingness to accept a loss is usually higher than their WTP for a gain (Shogren et al. 2001; Horowitz and McConnell 2002; Viscusi and Huber 2012). This study evaluates demand sensitivity to loss versus gain in a different setting in a developing country using two information frames. It investigates whether informing consumers about the negative *consequences of not having* enough iron in their diets (i.e., "loss frame") would lead to a higher demand, compared with when they are informed about the *benefits of having* enough iron in their diets (i.e., "gain frame").

Our aim was to understand whether an approach that encourages consumers to avoid loss works better than one that encourages consumers to realize gain in generating demand for nutritious food. Further, because it may affect consumer behavior and brand marketing (Hartmann and Viard 2008; Kopalle et al. 2012), we also investigated the effect of the frequency of providing information on consumer WTP to inform the design of cost-effective marketing strategies for iron beans, regardless of the media used to convey such information.

To meet the study's objectives, we used (1) a hedonic rating method to examine consumer evaluation of the sensory attributes of iron and local bean varieties, and (2) the Becker-DeGroot-Marschak (BDM) mechanism to elicit consumer WTP for these varieties (Lusk and Shogren 2007). We chose BDM over several preference-elicitation techniques because it is an incentive-compatible mechanism that was successfully implemented in rural areas (Banerji et al. 2013).

The study was conducted in the rural areas of Gakenke district, located in Rwanda's Northern Province. Three bean varieties were used for the study, two of which were iron bean varieties RWV 3316 (red) and RWV 3006 (white). The popular red mottled local variety used was *Mutiki*, which is about 40 percent lower in iron content than the iron bean varieties. The study was conducted in a home-use testing (HUT) setting; 572 respondents tested the three bean varieties at home over the course of 7 days. Each respondent was visited four times during this period.

Consumers in each village were randomly allocated to one control and four treatment groups. The control group (T1) was not given any information regarding the nutritional value of the iron bean varieties, whereas the four treatment groups were provided nutrition information through simulated radio messages. T2 listened to the "gain frame" information only once on the first visit, while T3 listened to the same gain information three times (once per visit for three visits in total). In contrast, T4 listened to the "loss frame" information only once on the first visit, while T5 listened to the same "loss frame" information three times (once per visit for three visits in total). The study compared WTP values across these five treatment groups.

Since standard theory suggests that initial endowments could distort optimal bidding behavior (Corrigan and Rousu 2006), a participation fee was not given in this study and participants paid out of pocket. Oparinde et al. (2014) successfully tested this approach in Nigeria, where more than 90 percent of respondents paid out of pocket. Considering the potential liquidity constraints at the time this study was conducted, participants who could not make out-of-pocket payments were allowed to purchase the product on credit, with a collection system effectively implemented by the farmers' leaders in each study location. Thus, the WTP results are also discussed by consumers' payment status (i.e., whether they paid on the spot or later).

The rest of the paper is organized as follows: section 2 presents the methodology, section 3 presents the data and empirical model, section 4 presents and discusses the results, and section 5 concludes the paper with implications for delivery and marketing of iron bean varieties in Rwanda.

2. METHODOLOGY

2.1 Consent and Ethical Review

The study underwent an ethical review process and was approved by the International Food Policy Research Institute Review Board and by the Rwanda Ministry of Education. Participants were informed about the study and were asked for their consent to participate.

2.2 BDM Mechanism

The BDM mechanism is widely implemented to elicit consumer acceptance of novel agricultural products in rural Africa (e.g., Banerji et al. 2013). In a BDM mechanism, an individual submits a bid (y) for a product being auctioned. The decision rule for "winning" the product is based on the comparison of the bid with a random price (p) drawn from a distribution (M) already established ex ante: the individual wins the product if the bid is greater than the random price, and pays price p. If $y < p$, the bidder does not win—i.e., does not get the product or pay a price. The individual's true WTP for a unit of the product is defined as the price that induces indifference between winning and not winning the unit. That is $u(1,w - WTP) = u(0,w)$, where w is the individual's resources at the beginning of the experiment. Rational behavior under this mechanism is to place a bid equal to WTP (Lusk and Shogren 2007).

$$max \int_0^{y_i} u(1,w\text{-}p)dM(p)+\int_{y_i}^{\overline{p}_i} u(0,w)\big(1\text{-}M(y)\big) \qquad (1)$$

A first-order condition of this expression (1) shows that the optimal bid solves ($u(1,w - y^*)=u(0,w)$), and is, therefore, equal to the WTP.

2.3 Study Area and Sampling Design

The study was conducted in Rwanda's Northern Province, one of the main bean-producing areas of the country. By the time it was conducted in the last quarter of 2013 (i.e., 2014 season A), several varieties of iron beans had been delivered across the country. Gakenke district in Northern Province was selected as the study site because it had minimal to no delivery and marketing activities.

A multi-stage cluster sampling procedure was employed to randomly select households within the district. The first stage involved the selection of sectors among the district's 19 sectors. The sectors were grouped into four quartiles using the 2008 population density figures. One sector was randomly selected from each quartile. The four selected sectors were Coko (Q1), Muyongwe (Q2), Karambo (Q3), and Mugunga (Q4). The second stage involved the selection of villages within each of these sectors. Given logistical considerations, one-fifth of all villages in each sector were randomly picked, and all households within the selected villages were listed. The third stage was the random sampling of households from the household lists.

The total sample size was determined by the following considerations. Binary comparisons of treatment groups are of primary interest. At the time of data collection, the price of bean grains in rural markets ranged from 250 to 750 Rwandan francs (RWF) per kilogram (kg) (US$ 1 ≈ 650 RWF). The total sample size was determined by the average treatment effect. On the one hand, a treatment effect of about 15 percent of the average market price, or 45 RWF, was considered to be a price difference that may be meaningful to a farm household. On the other hand, the average of treatment effects across recent consumer studies on biofortified sweet potato (Uganda), maize (Tanzania and Zambia), and fortified maize (Kenya) suggests that effects of 6 percent to 25 percent or even higher could be observed, corresponding to 18 to 75 RWF, respectively, with a standard deviation of 11 percent corresponding to 33 RWF (Kiria, Vermeulen, and De Groote 2010; Chowdury et al. 2011; De Groote et al. 2011; Meenakshi et al., 2012). Based on these previous results, we assumed (1) a 6 percent (or 18 RWF) difference in the response of matched pairs, (2) that this difference is normally distributed with a standard deviation of 35 RWF as a safe high assumption, and (3) that 60 RWF (roughly double) would appear to be a maximum expected standard deviation. This was considered a standard view based on previous studies. However, to have enough power, a lower effect size of 5 percent (or 15 RWF) was also considered to have a potentially significant value to poor farm households. This is referred to as a conservative view.

Using both the standard and the conservative views, power calculations were conducted for the four smallest detectable effect size/standard deviation (E/S) ratios (1/5, 1/4, 1/3, and 1/2). A significance level of 5 percent and a power of 0.8 were used, and treatments were randomized at the household level. Table 1 reports the required sample size *per treatment* for 15/60 and 18/60 E/S ratios. If the true difference in the mean response of matched pairs is 18 RWF, based on the aforementioned standard view a minimum of 89 households per treatment was required to be able to reject the null hypothesis that the response difference is zero with a probability (power) of 0.8. On the other hand, in order to use the conservative view with effect size of 15 RWF, 128 households were required per treatment. The conservative view was applied in most cases, while the standard view was applied in only some cases, given the budget and logistical considerations (see Table 1). The sampling consisted of 562 (plus an additional 10 for replacement) farming households that were randomly drawn proportionate to size from the household list.

Table 1: Sample size by experimental group

Sample sizes	T1: Control	T2: Treatment	T4: Treatment	Total
	No information	"Gain frame" information + listen *once*	"Loss frame" information + listen *once*	
Sample Size 1	128	128	128	384
		T3: Treatment	**T5: Treatment**	
	–	"Gain frame" information + listen *three times*	"Loss frame" information + listen_*three times*	
Sample Size 2	–	89	89	178

2.4 Sensory Evaluation and WTP Elicitation Procedure

Each sampled household was visited the day before the study. Respondents were the household members over the age of 18 who are mainly responsible for deciding which bean variety to purchase or cook for home consumption. Once the respondents agreed to participate in the study, their households were visited the next day. Participants were randomly allocated into treatment and control groups. In a few cases where participants had heard about iron bean varieties before the survey, they were randomly allocated to any of the treatment groups (T2–T5), in order to have a control group without any information. While this allocation is not necessary and may result in a selection bias, its effect is expected to be negligible, since the study was conducted in locations where iron bean delivery and marketing activities are non-existent or minimal. After this random allocation step, participant- and household-level Subsequently, participants were asked to undertake sensory evaluation of the three bean varieties (red mottled local, red iron bean [RIB], and white iron bean [WIB]), and participate in the bean-purchasing game in the following 7 consecutive days. Sensory evaluation protocols from food science literature were followed (Tomlins et al. 2007; Talsma et al. 2013). Raw grains for each bean variety were packed in 1-kg paper bags, and the order in which they were given was randomized across participants. Control group participants were told which of the varieties was local and which were new. In contrast, treatment group participants were informed which of the varieties was local and which were iron bean varieties.

Prior to receiving the first bean variety, participants in the treatment groups listened to one of the radio messages, depending on their group. T2 participants listened *once* to a 1-minute "gain frame" radio message about the health benefits of conswuming iron bean varieties and of having enough iron in their diets, while T3 participants listened to the same "gain frame" message *three times* (once per visit during the three visits). In contrast, T4 participants listened *once* to the “loss frame” message about the iron bean varieties and the consequences of not having enough iron in their diets, while T5 participants listened to the same message *three times* (once per visit, three visits in total). The radio messages were in the widely spoken local language (Kinyarwanda), and were conveyed through MP3 players (see the appendix for the English texts of the messages used). On the first visit (day 1), all participants were given 1 kg of raw/uncooked grains of the first variety and were told that they would be revisited in 2 days’ (day 3) time. The interval would give the participants sufficient time to cook, consume, and test the variety overnight with other household members. On the second visit (day 3), participants evaluated the sensory characteristics of the first variety given—i.e., color, raw and cooked bean sizes, taste, cooking time, overnight keeping quality, and ease of breaking. These characteristics were determined through focus group discussions with farmers and other actors along the value chain. Participants’ evaluations were based on a 7-point Likert scale (i.e., 7. Like very much, 6. Like moderately, 5. Like slightly, 4. Neither like nor dislike, 3. Dislike slightly, 2. Dislike moderately, 1. Dislike very much). On day 3, participants were given 1 kg of raw grains of the second variety, and were then revisited on day 5. On this third visit (day 5), they were asked to evaluate the sensory characteristics of the second variety and were given 1 kg of raw grains of the third variety. On the day of the final visit (day 7), participants were asked to evaluate the sensory characteristics of the third variety.

The BDM experiment was conducted on the last visit (day 7) to elicit participant WTP for each of the three varieties evaluated over the 7 days. Before participants were asked to state their WTP for each variety, they were introduced to the BDM experiment. The instruction emphasized the possibility of a participant buying one of the varieties evaluated and paying out of pocket. Enumerators explained to the participants that their optimal strategy was to state a bid equal to their true WTP for each of the three varieties. In particular, it was explained that stating a bid higher than their true WTP could result in their having to buy the beans at a price higher than what they were willing to pay, whereas stating a bid lower than their true WTP could result in their losing a profitable opportunity to buy. Participants were also told about the distribution of prices from which the random (competing) price was to be drawn. By using numerical examples, enumerators further emphasized that the optimal strategy was for participants to state their true WTP. Following this explanation, participants were taken through a practice round with biscuits to familiarize them with the instructions and steps in the BDM mechanism.

Participants were next asked to state separate bids (their WTP) for 1 kg of each variety evaluated. They were then asked to draw the “binding” variety, by randomly picking a chip from an opaque bag that contained three chips corresponding to each of the three varieties. For this binding variety, each participant was asked to draw a sale price by randomly selecting a price strip from a bag that contained 16 strips with a uniform distribution (250, 350, ... 1,000 RWF) around the prevailing market price of the local variety. If the participant’s stated WTP for this binding variety exceeded the sale price drawn, the participant would “win” 1 kg of bean grain of this variety, and pay a price equal to the sale price out of pocket; if the sale price was higher than the stated WTP, the variety was not sold.

Apart from immediate payment out of pocket, participants were also given the option of purchasing on credit at zero percent interest rate. These participants were asked to specify a payment date, and were instructed to pay the amount owed to the farmers’ leader in their community who remits the money to the study team via mobile money. A payment contract agreement was signed between the participant and the enumerator. Participants only became aware of the credit option after the BDM experiment was completed, and once they declared their inability to pay out of pocket. The goal here is not to test the effect of credit facilities on WTP, but rather to identify the nature of hypothetical bias in cases of non-payment. Also, because credit facilities are generally scarce among the rural poor in developing countries, it is less likely that consumers would be able to purchase iron beans on credit in the market.

2.5 Measurement Issues

The study’s estimations needed to address two measurement issues. Estimates of WTP for the treatment groups may suffer from social interaction effects and prior knowledge selection bias. First, social interactions among participants could occur within the village, on farms, and in common meeting places, such as the market. Participants in the treatment groups can contaminate the control group with information; likewise, control group participants can contaminate the treatment groups via experience sharing. One way to potentially minimize such effects would be to use a cluster-randomized design, where randomization is done at the village level. However, since Rwanda is a relatively small country and the villages are within very close proximity of one another, it is practically impossible to avoid social interactions among participants. Therefore, randomizing at the village level would suffer from the same social interaction bias as randomizing at the household level.

Considering this constraint, the study followed the option of randomizing at the household level, with a small time lag between control and treatment interviews within each selected village. The control group interviews were conducted in the first week, and treatment group interviews were randomized across four subsequent weeks as a strategy to avoid information contamination from the treatment groups. While this strategy assists in removing information spill from treatment to control, there is still potential contamination as a result of experience sharing from control to treatment. Second, since participants with prior knowledge of iron beans were allocated to treatment groups only, this could introduce some selection bias. These issues are investigated in subsequent analysis presented in sections 3 and 5

3. DATA AND EMPIRICAL STRATEGY

3.1 Respondent and Household Characteristics

Key household- and participant-level social and economic characteristics that are hypothesized to have an effect on consumer sensory evaluation and WTP are presented in Table 2, by treatment group. Overall, almost two-thirds (62 percent) of participants were aware of anemia. A majority of the social and economic characteristics is not significantly different across treatment groups, suggesting that the results are comparable across groups. However, there are significant differences across treatment groups for three household-level characteristics: (1) participants in T4 have significantly larger households than participants in T5 (p-value <0.05); (2) although on average participants' households in the study area consumed beans twice a day, in the last 24 hours, participants' households in T5 consumed significantly more frequently than those in T4 (p-value <0.10); and (3) at the time of the survey, about one-third (29 percent) of all households had beans at home, with an average quantity of 6 kg (for the pooled sample).

This ex ante product endowment could have an effect on participants' valuation of and purchase decisions on the three varieties tested. On average, 59 percent of the beans consumed by the participants' households was sourced from their own production, and 37 percent was sourced through market purchases. Also, about 17 percent of households (pooled sample) obtained all of the beans they consumed in the previous (2013 B) season from their own production, suggesting that they are self-sufficient. Compared with T1, a significantly higher proportion of T2 participants' households sourced their bean consumption from their own production (p-value <0.10).

Since farmers are also simultaneously considered consumers in this study, it is possible that the participants may have perceptions about the agronomic qualities of the beans tested. Unfortunately, in order to minimize interview time per participant, information on this variable was not collected. Even though 7 percent of the participants had heard of iron beans before the survey, only one participant planted iron beans in the 2013 B season before the survey. However, information was collected on whether the participants' households cultivated any improved variety in the season. About 18 percent of the participants' households planted an improved bean variety in the season, and a majority of them reported yield (95

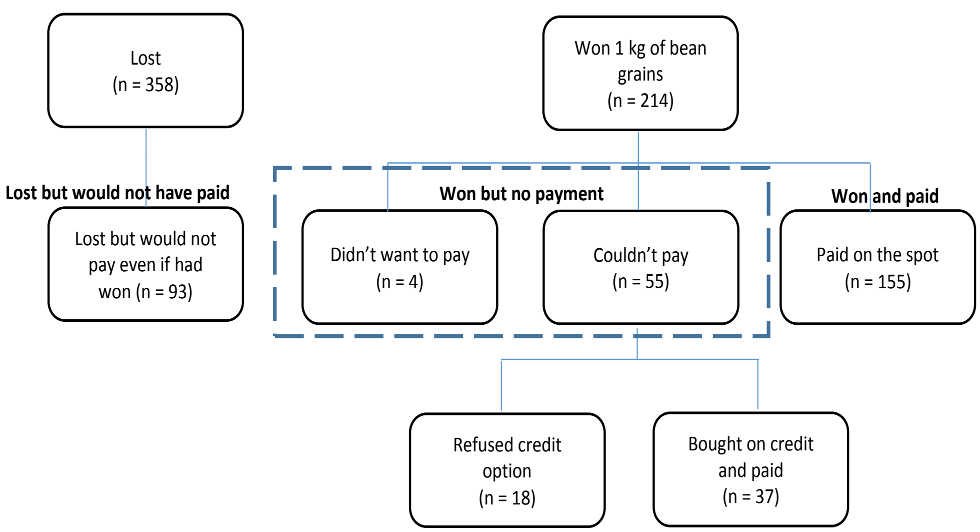

Figure 1: Diagrammatic Representation of Survey Participants, by Payment Status

Table 2. Socioeconomic characteristics, by treatment group

Variable	Definition (Key participant and household characteristics)	T1 – no information	T2 – "gain frame" information & listen once	T3 – "gain frame" information & listen 3 times	T4 – "loss frame" information & listen once	T5 – "loss frame" information & listen 3 times
		N = 127	N = 132	N = 94	N = 126	N = 93
Participant						
Male	1 if participant's gender is male	51%	43%	49%	41%	45%
Aware of anemia	1 if participant is aware of anemia	61%	62%	61%	63%	61%
Aware of iron beans*	1 if participant has heard of iron bean varieties before survey	0%	10%	12%	5%	8%
Variety decision maker	1 if participant is the main decision maker on bean variety for home consumption	64%	71%	70%	74%	72%
Listen to radio	1 if participant listens to radio	85%	77%	79%	81%	76%
Age	Participant age in years	43.5 (14.8)	42.7 (14.2)	45.9 (17.3)	44.7 (16.2)	46.0 (17.7)
Education	Participant education in years	3.9 (2.9)	3.5 (3.3)	3.4 (3.0)	3.3 (3.0)	3.7 (3.5)
Participant's household						
Household size*	Household size	4.8 (1.9)	4.6 (1.7)	4.3 (1.8)	4.7 (1.8)	4.1 (1.7)
Plant beans in season B	1 if participant's household planted beans in 2013 season B	95%	95%	95%	92%	91%
Plant beans in season A	1 if participant's household planted beans in 2014 season A	93%	96%	98%	98%	98%
Bean area in season B (ha)	Area of land in hectares planted with beans by the participant's household in 2013 season B	0.2 (0.3)	0.2 (0.5)	0.2 (0.6)	0.3 (0.6)	0.3 (0.4)
Bean area in season A (ha)	Area of land in hectares planted with beans by the participant's household in 2014 season A	0.2 (0.4)	0.2 (0.2)	0.2 (0.3)	0.2 (0.3)	0.3 (0.5)
Beans status & consumption at home						
Household has beans at home	1 if participant's household had beans at home at time of survey	29%	30%	24%	27%	35%
Household has high-iron beans (HIBs) at home	1 if participant's household had HIBs at home at time of survey	0%	0%	0%	0%	0%
Bean consumption frequency (last 24 hours)	No. of times the household consumed beans in the last 24 hours	1.9 (0.4)	1.9 (0.4)	1.9 (0.4)	1.9 (0.3)	2.0 (0.3)
Total quantity of beans at home (kg)	Quantity (kg) of beans participant had at home	3.9 (12.2)	4.6 (16.0)	4.1 (14.1)	8.2 (63.0)	10.7 (73.2)
% beans from own production*	Percentage of total quantity of beans consumed by the household in 2013 season B that was sourced from own production	56.5 (29.3)	63.5 (30.2)	60.8 (31.3)	57.7 (31.2)	57.7 (29.7)
% beans from market purchase	Percentage of total quantity of beans consumed by the household in 2013 season B that was purchased at market	40.7 (29.5)	36.1 (28.9)	37.9 (29.0)	38.5 (30.8)	37.2 (28.9)
% of self-sufficient households	Percentage of households that sourced 100% of beans consumed in 2013 season B from *own production*	13%	21%	21%	15%	13%
Payment status						
Won beans	1 if participant won beans	43%	37%	34%	35%	39%
Lost	1 if participant did not win beans	57%	63%	66%	65%	61%
Won and paid	1 if participant won beans and paid	22%	28%	26%	29%	33%
Won and couldn't pay	1 if participant won beans and couldn't pay	20%	9%	6%	5%	7%
Won and didn't pay	1 if participant won beans and didn't want to pay	1%	0%	2%	1%	0%
Refused credit	1 if participant won and couldn't pay but still did not buy on credit	6%	3%	4%	3%	4%
Lost but wouldn't have paid	1 if participant lost but wouldn't pay if had won	21%	12%	20%	14%	16%

*One-sided t-tests and Pearson chi-square tests reveal statistically significant differences in participant/household characteristics across treatment arms; () = standard deviation.

percent) and market demand (12 percent) as the primary reasons for the cultivation. It can be expected that participants from households with experience planting improved varieties may have different perceptions of the agronomic qualities of the bean varieties tested, compared with participants from households without such experience. Thus, in the regression analysis discussed, whether a participant's household planted improved varieties is controlled for.

To address the measurement issue introduced by allocating participants with a priori knowledge of iron beans to treatment groups only, their socioeconomic characteristics were compared with those of others, as shown in Table 3, to identify whether there is a systematic difference. The t-test accounts for the unequal sample sizes. The test result suggests that participants with a priori knowledge significantly have more years of education and consume more beans from their own production than those without a priori knowledge. Using a binary probit regression with a priori knowledge (Yes = 1; otherwise, 0) as the dependent variable and all the variables listed in Table 3 as explanatory, education is the only significant variable (beta = 0.093, p = 0.003). This suggests that an interaction term between a priori knowledge and education may have an effect on WTP.

Table 3: Socioeconomic characteristics, by prior knowledge of iron beans

Variable	No prior knowledge (control)	No prior knowledge (treatment)	Prior knowledge (treatment)	F-test	Welch-Satter-thwaite t-test with unequal variances
	(1)	(2)	(3)		
	N = 127	N = 408	N = 37	F statistic	Significance
Aware of anemia	61%	61%	70%	0.55	
Male	51%	43%	62%	3.58**	
Age	43.5 (14.8)	44.7 (16.3)	43.0 (14.7)	0.44	
Education (years)	3.9 (2.9)	3.3 (3.2)	5.1 (3.0)	6.57***	(2 vs. 3)*** (1 vs. 3)**
Household size	4.8 (1.9)	4.4 (1.8)	4.6 (2.0)	1.60	
Bean area in season B (ha)	0.2 (0.3)	0.2 (0.5)	0.3 (0.9)	0.87	
Grow improved beans	24%	18%	21%	1.23	
% beans from own production	56.5 (29.3)	59.5 (30.3)	67.0 (33.5)	1.72	(1 vs. 3)*
Don't buy beans	4%	5%	5%	0.16	
Bean consumption frequency (last 24 hours)	1.9 (0.4)	1.9 (0.4)	1.9 (0.4)	0.17	
Per capita quantity of beans at home (kg)	1.1 (5.0)	1.6 (12.6)	2.1 (4.2)	0.17	
Wealth index	0.4 (0.2)	0.3 (0.2)	0.4 (0.2)	2.57*	(1 vs. 2)**

*Significant at 10% level, **significant at 5% level, ***significant at 1% level.

Although the participants were informed that if they "won" a pack of beans in the BDM experiment they would have to make an out-of-pocket payment to purchase it, some participants were unable to pay or did not want to pay after "winning" (see Figure 1). Of the 214 participants who "won" in the BDM game, only 2 percent did not want to pay, while more than one-quarter (26 percent) could not pay at the time due to financial constraints. Of the 358 participants who did not win, more than a quarter (26 percent) also stated that they would not have paid had they won in the BDM game. Interestingly, the proportion of participants with observed non-payment is similar to the proportion of participants who have non-payment intentions. The fact that the percentages are similar may suggest that "lost but would not have paid" participants might have truthfully revealed their intentions, since they are drawn from the same population. A majority of participants who did not (or would not) make a payment stated lack of money as the primary reason (Figure 2).

Of interest is whether the participants who won and paid and those who lost but would not have paid are systematically different. The key socioeconomic characteristics of these participants are presented and compared in Table 4. Participants who won and paid and those who lost but would not have paid did not significantly differ in the quantity of beans at home, which could influence a purchase decision. However, "won but no payment" participants had more beans at home and were generally more educated. It is possible that these participants' bids were also different from those of the participants who won and paid. Further, a module on the Household Food Insecurity Access Scale (HFIAS) was included in the survey. This module was developed following the FANTA (Food and Nutritional Technical Assistance) guidelines (Coates et al. 2007). The HFIAS included nine food access questions of three categories, with an overall score ranging from 0 to 27 for each household. As shown in Table 4, "won and paid" participants are less food insecure on average than either the "won but no payment" participants or the "lost but would not have paid" participants. This suggests that food access may be a contributing factor to participants' WTP.

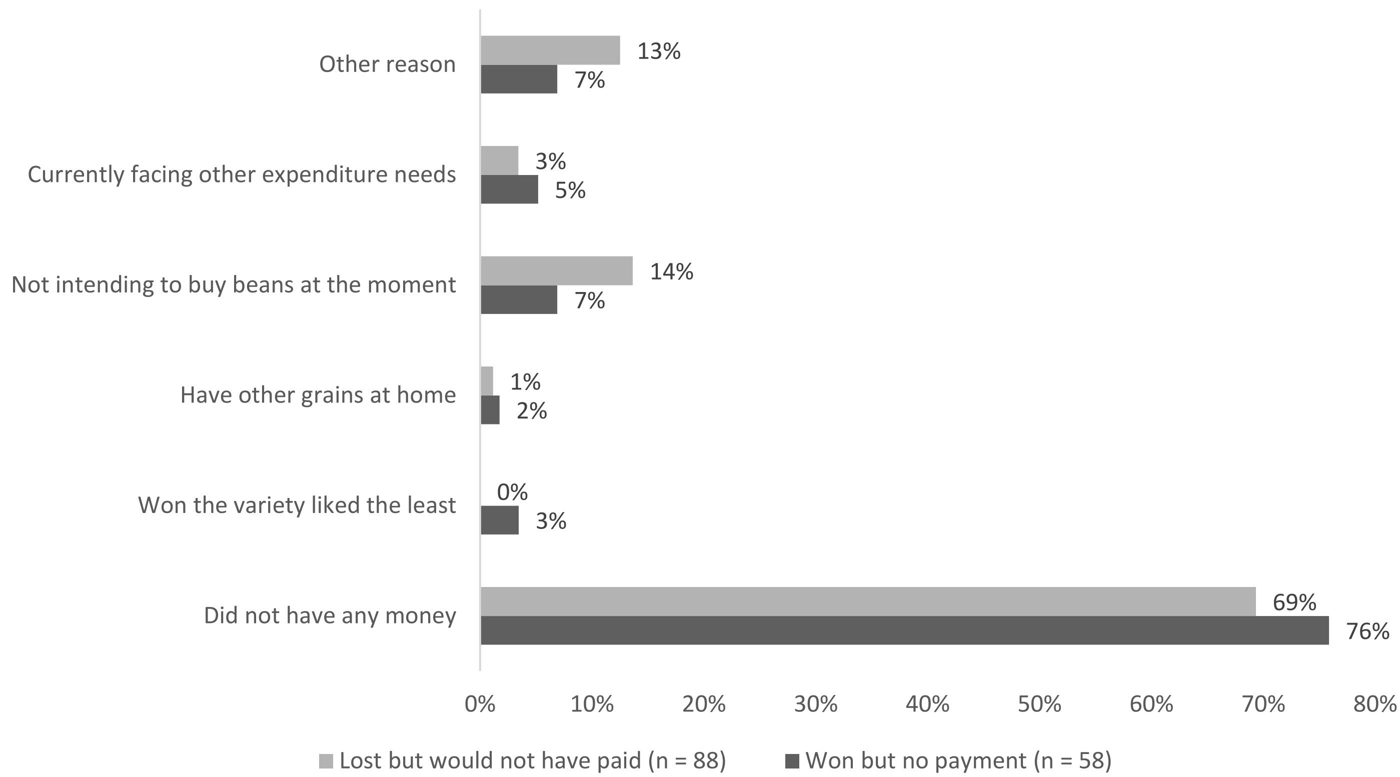

Figure 2: Participants' Reasons for Non-Payment

Table 4: Socioeconomic characteristics, by payment status

Variable	Pool sample	Won and paid	Won but no payment	Lost but would not have paid	t-test	
	N = 572	N = 155	N = 59	N = 94	A	B
Aware of anemia	60%	60%	70%	60%		
Age	44.3 (15.9)	44.0 (15.6)	40.9 (13.4)	46.1 (17.3)		*
Education (years)	3.5 (3.1)	3.6 (3.2)	4.1 (3.1)	2.7 (2.8)	**	***
Household size	4.5 (1.8)	4.6 (1.9)	4.6 (1.6)	4.3 (4.3)		
Bean area in season B (ha)	0.2 (0.5)	0.3 (0.7)	0.2 (0.2)	0.2 (0.3)		
Bean consumption frequency (last 24 hours)	1.9 (0.4)	2.0 (0.3)	1.9 (0.3)	1.8 (0.4)	***	**
Total quantity of beans at home (kg)	6.1 (43.2)	9.3 (58.1)	5.4 (15.8)	1.1 (4.5)		**
Per capita quantity of beans at home (kg)	1.5 (10.9)	2.2 (14.5)	w1.8 (7.2)	0.3 (1.1)		**
Wealth index	0.3 (0.2)	0.3 (0.2)	0.3 (0.2)	0.3 (0.2)		
					A	C
HFIAS	9.7 (6.7)	8.4 (6.4)	11.2 (6.5)	10.9 (6.7)	***	***

Notes: A: one-sided t-test between "won and paid" vs. "won but no payment"; B: one-sided t-test between "won but no payment" vs. "lost but would not have paid"; C: one-sided t-test between "won and paid" vs. "lost but would not have paid." ***Significant at 1%, **significant at 5%, *significant at 10%; () = standard deviation.

3.2 Sensory Evaluation and WTP Data

The mean hedonic scores for sensory characteristics are shown in Table 5, by treatment groups. (Mean values are reported instead of percentages because of space constraints; percentage distributions are available from the authors upon request.) While most participants scored all products 5 or above (i.e., 5. "Like slightly," 6. "Like moderately," or 7. "Like very much"), in each treatment, the mean scores are statistically significantly different across the three bean varieties evaluated.

Comparisons within treatment groups reveal that participants in all groups rated all the sensory attributes of the RIB variety highest, followed by the local variety, while the WIB variety scored the lowest. The difference in mean scores between local and RIB varieties is significant for all attributes in almost all treatments, expect for raw bean size and cooking time. Although the WIB variety is liked the least across treatments, all groups rated its cooking time significantly higher than that of the local variety. While the control group participants also rated the cooking time of the WIB variety higher than that of the RIB variety, information appears to eliminate this since the score for this attribute is not significantly different for the two varieties in all treatment groups. However, the WIB variety is not particularly liked for its color, compared with either the RIB or the local variety. The difference between participants' overall liking for the attributes of iron bean variety relative to their overall liking for the attributes of the local variety was computed for both RIB and WIB. This difference is included as a control variable in the regression analysis discussed later.

During the study period, bean grain prices were collected daily in the markets nearest to the study villages. In each market, prices were collected from two to seven randomly selected sellers, depending on the size of the market. The observed market price for the local variety per kg ranged from 240 to 750 RWF, averaging at 540 RWF (Figure 3). Bids submitted for the local variety are also within a similar wide range, but some participants' bids are outside the observed market price range (i.e., bids for the local variety range from 150 to 900 RWF). This is surprising, because it would be expected that consumers should at least bid the price at which they can buy the local variety in the market.

Table 5: Mean hedonic rating of bean grain varieties, by treatment and comparisons within each treatment group[a]

	Bean variety	Raw bean dryness	Raw bean color	Raw bean size	Cooked bean size	Taste+	Cooking time	Overnight keeping quality	Ease of breaking+	Overall
Control (T1)	Local	5.89	6.11	5.91	6.01	5.86	6.09	6.03	6.07	5.99
	RIB	6.15	6.44	6.05	6.57	6.20	5.68	6.34	6.16	6.38
	WIB	5.73	4.81	5.71	5.82	5.51	6.18	5.26	5.39	5.35
	Difference in means									
	Local vs. RIB	−0.26*	−0.33***	−0.14	−0.56***	−0.35**	0.40***	−0.31**	−0.09	−0.39***
	Local vs. WIB	0.16	1.29***	0.20	0.19	0.34**	−0.10	0.77***	0.68***	0.64***
	RIB vs. WIB	0.42***	1.62***	0.34***	0.75***	0.69***	−0.50***	1.08***	0.77***	1.03***
T2	Local	6.16	6.22	6.08	6.23	5.96	5.99	6.35	6.31	6.20
	RIB	6.48	6.80	6.25	6.81	6.54	6.28	6.63	6.59	6.69
	WIB	5.85	4.84	6.04	5.95	5.79	6.43	5.25	5.20	5.23
	Difference in means									
	Local vs. RIB	−0.32***	−0.58***	−0.17*	−0.58***	−0.58***	−0.30***	−0.28***	−0.28***	−0.48***
	Local vs. WIB	0.31**	1.38***	0.04	0.27**	0.17	−0.44***	1.10***	1.11***	0.98***
	RIB vs. WIB	0.63***	1.96***	0.21**	0.85***	0.75***	−0.15	1.38***	1.40***	1.46***
T3	Local	6.15	6.24	6.33	6.27	5.97	5.90	6.32	6.35	6.11
	RIB	6.69	6.72	6.45	6.71	6.56	6.35	6.76	6.66	6.66
	WIB	6.03	4.71	5.94	6.00	5.56	6.50	5.00	5.46	5.26
	Difference in means									
	Local vs. RIB	−0.54***	−0.47***	−0.12	−0.45***	−0.60***	−0.45***	−0.44***	−0.31***	−0.56***
	Local vs. WIB	0.12	1.53***	0.39***	0.27**	0.41***	−0.60***	1.32***	0.89***	0.84***
	RIB vs. WIB	0.66***	2.01***	0.51***	0.71***	1.00***	-0.10	1.75***	1.20***	1.40***
T4	Local	6.12	6.33	6.19	6.25	5.95	6.03	6.45	6.26	6.12
	RIB	6.54	6.76	6.42	6.71	6.53	6.29	6.66	6.58	6.73
	WIB	5.86	4.50	5.89	5.91	5.24	6.39	4.94	5.22	5.11
	Difference in means									
	Local vs. RIB	−0.42***	−0.44***	−0.23***	−0.46***	−0.58***	−0.26**	−0.21**	−0.33***	−0.61***
	Local vs. WIB	0.26*	1.82***	0.30***	0.35**	0.71***	−0.36***	1.51***	1.04***	1.01***
	RIB vs. WIB	0.68***	2.26***	0.54***	0.81***	1.28***	−0.11	1.72***	1.36***	1.62***
T5	Local	6.16	6.02	6.24	6.06	5.91	6.05	6.39	6.28	6.09
	RIB	6.61	6.70	6.20	6.80	6.51	6.22	6.69	6.55	6.71
	WIB	6.02	4.95	5.95	6.30	5.77	6.25	5.25	5.20	5.10
	Difference in means									
	Local vs. RIB	−0.45***	−0.68***	0.03	−0.74***	−0.60***	−0.16	−0.30***	−0.27**	−0.63***
	Local vs. WIB	0.14	1.07***	0.28*	−0.24	0.14***	−0.20	1.15***	1.08***	0.98***
	RIB vs. WIB	0.59***	1.75***	0.25***	0.50***	0.74***	−0.03	1.45***	1.35***	1.61***

[a] Standard deviations available from authors upon request.

***Significant at 1%, **significant at 5%, *significant at 10% (one-sided t-test), +after cooked well without salt or ingredients.

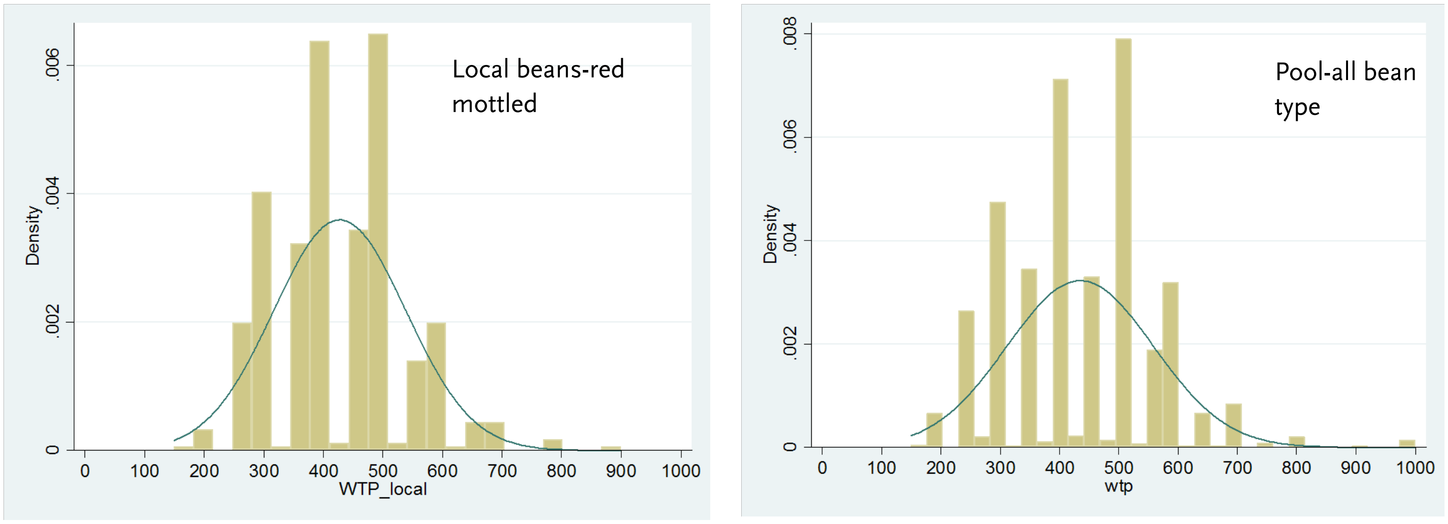

Figure 3: Distribution of WTP for 1 Kg of beans in RWF

Seven participants (1 percent) submitted bids below 240 RWF and four participants (0.7 percent) submitted bids above 750 RWF for the local variety. For the former, three of them would not have paid or could not pay in the BDM experiment, while one had beans at home. Similarly three of the latter would not have paid or could not pay. For the pooled sample (i.e., all three varieties), 2 percent of the bids were below 240 RWF, while less than 1 percent were above 750 RWF. As shown in Figure 3, these bids may be outliers, which could have been due to the potentially hypothetical nature of the bids submitted by "won but no payment" and "lost but would not have paid" participants.

The mean WTP of "won but no payment" participants is significantly higher than those of "won and paid" participants by 13 percent, 12 percent, and 18 percent for local, RIB, and WIB varieties, respectively (see Table 6). As a result, this study's estimations focus on the difference in WTP. Since this study is interested in understanding how much premium, D, participants have for each of the iron bean varieties relative to the local variety, the premium was computed as the difference between WTP for each iron bean variety and WTP for the local variety, as shown in Table 6.

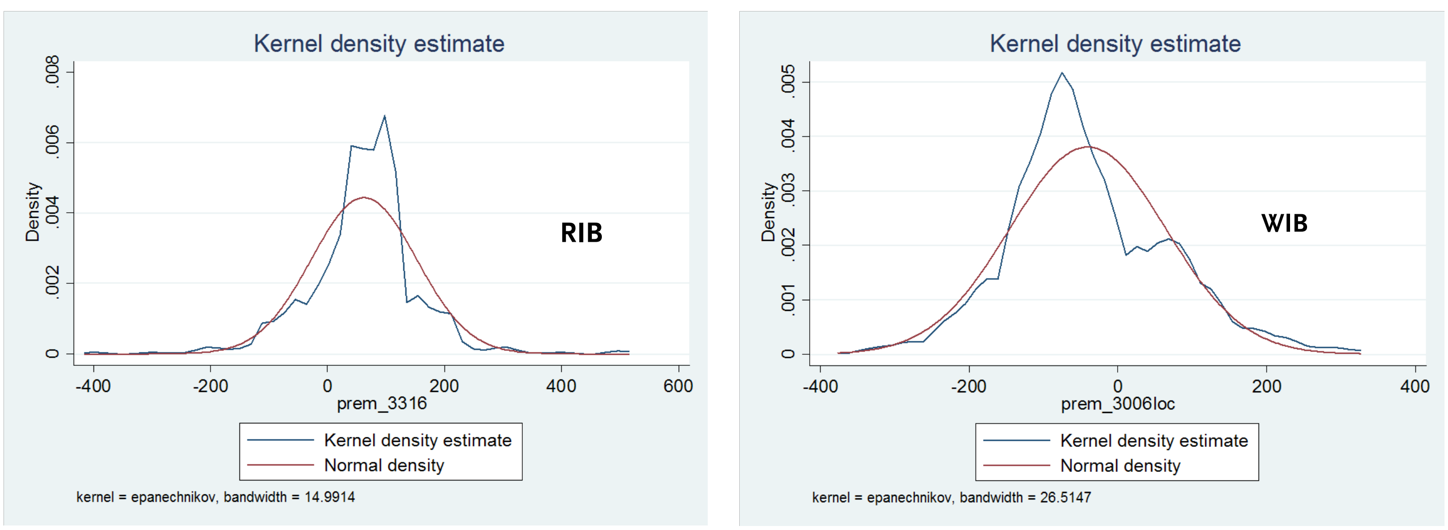

Figure 4: Distribution of difference in WTP for 1 Kg of beans in RWF relative to the local variety

Figure 4 presents the density function of the premium for RIB and WIB. The figure does not clearly suggest that the distributions are skewed, and various transformations of these data did not yield a better distribution. However, although the mean WTPs are significantly different between participants' categories shown in Table 6, their premiums are not significantly different, which suggests that the bid difference could have eliminated the non-payment effect. Meanwhile, this is tested further in the regression analysis presented later.

The treatment effect on the premium for iron beans is of particular interest. Thus, it was assumed that participant *i*'s premium for a particular product, *j,* is determined by the participant's sensory liking for the product, S_i, a vector of participant characteristics, Z_i, as well as a vector of experimental variables, T_i. Although there are three varieties, the difference in bids eliminates the need to control for the individual-specific effect. Therefore, the following equation was estimated using ordinary least squares (OLS) regression:

$$D_i = \alpha + \beta' \ T_i + \theta' \ S_i + \gamma' Z_i + e_i \ , \qquad (2)$$

where e_i represents the normally distributed error term and β, θ and γ are parameters of interest.

Equation 2 was estimated for each iron bean variety. To examine the robustness of the estimation strategy, further analysis is provided by considering various issues previously discussed. First, we investigated if the premium estimation is sensitive to non-payment by estimating two model types: one with a full sample and the other with a partial sample, where participants who could not or would not have paid are excluded. This allows an examination of the existence of hypothetical bias in participant premium for iron beans. We also estimated another model where a dummy variable controlling for the payment status (won but no payment/lost but would not have paid = 1; otherwise, 0) was included. Again, it could be argued that those bids where there is an actual or intended non-payment are actually zeroes, since the participants would not or could not pay their bids.

Therefore, we also computed mean bid difference when zero bids are taken into account (see Table 6). Thus, for participants who could not or would not have paid, it was assumed that their true WTP lies between zero and the bids submitted. Therefore, an interval-censored regression model (*intreg* command in STATA) was also estimated, where two assumptions were made for participants who could not or would not have paid. First, for participants with non-payment where the premium is greater than zero (+D), it was assumed that the lower limit is zero and the upper limit is the premium, such that $0 \leq D^* \leq +D$. Second, for non-payment participants where the premium is less than zero, we assumed that the lower limit is the premium (–D) and the upper limit is zero, such that $-D \leq D^* \leq 0$. And for the remaining participants who paid or would have paid, we assumed that their bids are equal to their WTP, such that the bid difference is uncensored. Further regression models were estimated where variables controlling for social interactions were introduced.

4. RESULTS AND DISCUSSIONS

4.1 WTP for Iron Beans

Table 6 reports average WTP for each of the varieties, as well as the difference in means within and across treatment groups. Participant mean WTP falls within the market price range observed at the time of the study. Based on the pooled sample of all participants across all treatments (regardless of payment status), the mean WTP is 428 RWF/kg for the local variety, 490 RWF/kg for the RIB variety, and 387 RWF/kg for the WIB variety. This ranking is similar for each treatment group—i.e., participants are willing to pay the most for the RIB variety and the least for the WIB variety. The WTP results are consistent with the participants' hedonic rating of the sensory attributes of the three varieties (Table 5). Participants in the control group (T1, no information) are on average willing to pay 476 RWF/kg for the local variety. Compared with the local variety, T1 (control) participants are willing to pay a premium of about 7 percent for the RIB variety and a discount of about 11 percent for the WIB variety. In all of the treatment groups with information (T2, T3, T4, and T5), the RIB variety was valued at a premium ranging from 13 percent to 17 percent, compared with the local variety. In contrast, in all information treatments, the WIB variety was valued at a discount ranging from 6 percent to 14 percent, compared with the local variety. This suggests that, compared with the control group, participants who received information in treatment groups 2–5 were willing to pay a higher premium for the RIB variety.

Although the bid differences within treatment groups have been discussed, the mean total bids when compared across treatment groups show that control group participants submitted the highest WTP for each of the three varieties on average, which is surprising. This higher WTP may be due to the social interaction bias. It is possible to assume that some participants who won (and were asked to make an out-of-pocket payment) in the control and treatment groups could have interacted with other treatment group participants by informing them that if they won, they would have to pay, leading the informed participants to lower their bids in the BDM experiment.

Table 6: Consumer willingness to pay for 1 kg of high-iron beans (rural Northern Province in Rwanda)

		Mean WTP (std. dev.)			Mean difference in WTP in RWF/kg (std. dev.)					
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Local	RIB	WIB	RIB–local	%	WIB –local	%	WIB–RIB	%
T1: No information	Group average (N = 127)	476.1	509.1	429.8	33.1**	6.5	−46.2***	−10.8	−79.3***	−18.5
		(130.6)	(120.3)	(137.9)	(96.6)		(116.3)		(112.1)	
T2: “Gain frame” information + listening *once*	Group average (N = 132)	424.8	488.4	378.0	63.6***	13.0	−46.7***	−12.4	−110.4***	−29.2
		(104.5)	(112.8)	(109.2)	(86.7)		(94.8)		(103.1)	
T3: “Gain frame” information + listening *three times*	Group average (N = 94)	400.3	479.4	373.0	79.0***	16.5	−27.3	−7.3	−106.4***	−28.5
		(105.4)	(121.0)	(120.9)	(85.7)		(94.5)		(110.1)	
T4: “Loss frame” information + listening *once*	Group average (N = 126)	413.6	478.2	363.5	64.6***	13.5	−50.1***	−13.8	−114.7***	−31.6
		(91.2)	(105.6)	(111.1)	(86.3)		(106.6)		(119.1)	
T5: “Loss frame” information + listening *three times*	Group average (N = 93)	411.6	492.7	387.3	81.1***	16.5	−23.9	−6.3	−105.4***	−27.2
		(102.5)	(112.1)	(123.6)	(85.4)		(108.7)		(115.7)	
Overall	Full sample (N = 572)	427.5	490.0	387.0	62.4***	12.7	−40.5***	−10.5	−103.0***	−26.6
		(111.0)	(114.4)	(122.7)	(89.9)		(104.9)		(112.3)	
	Full sample **with zero bids** (N = 572)	304.0	350.7	272.2	46.3***	13.3	−31.8***	−11.7	−78.5***	−28.9
		(202.8)	(277.4)	(189.9)	(75.6)		(88.8)		(99.0)	
	Won and paid (N = 155)	437.0[a]	498.3[a]	388.7[a]	61.3***	12.3	−48.3***	−12.4	−109.6***	−28.2
		(104.6)	(96.8)	(126.1)	(84.7)		(122.6)		(119.2)	
	Won but no payment (N = 59)	499.2	568.3	472.0	69.2***	12.2	−27.2	−5.8	−96.3***	−20.4
		(133.8)	(161.7)	(143.8)	(122.7)		(121.3)		(177.3)	
	Lost but would not have paid (N = 94)	443.2[b]	496.0[b]	406.9[b]	52.8***	10.6	−36.3**	−8.9	−89.1***	−21.9
		(116.4)	(125.8)	(130.0)	(99.6)		(110.4)		(106.1)	
Across treatments comparison of difference in WTP		**(RIB–local) *minus* T1 (RIB–local)**		**t-statistic**	**(WIB–local) *minus* T1 (WIB–local)**		**t-statistic**	**(WIB–RIB) *minus* T1 (WIB–RIB)**		**t-statistic**
	T2 vs. T1 (all participants)	30.6***		−4.7***	−0.5		0.1	−31.1***		2.4***
	T2 vs. T1 (won and paid)	15.7		−1.2	−23.4		1.2	−39.1**		1.3**
	T2 vs. T1 (won and paid + lost will pay)	32.9***		−4.3***	−2.9		0.3	−35.7***		1.9****
	T4 vs. T1 (all participants)	31.5***		−4.8***	−3.8		0.5	−35.4***		2.47***
	T4 vs. T1 (won and paid)	44.3***		−3.3***	−4.6		0.2	−48.9***		1.6***
	T4 vs. T1 (won and paid + lost will pay)	40.9***		−5.7***	−6.7		0.7	−47.5***		2.3***

[a]Mean WTP for “won and paid” is significantly different from that for “won but no payment” at 1% level.
[b]Mean WTP for “won but no payment” is significantly different from that for “lost but would not have paid” at 1% level.
is the corresponding comparison group.
***1% significance level, **5% significance level, *10% significance level (one-sided t-test).

Thus, at the end of the BDM experiment, all participants (control and treatment groups) were asked whether they had a conversation about the study with anyone within their social network (within or outside their villages). The responses obtained are assumed to be accurate and to reflect interactions among participants. About 53 percent reported to have had a conversation about the study (10 percent in the control group and 43 percent in the treatment groups). Each participant spoke about the study with five people on average; this is not significantly different across treatment groups. Of this 53 percent, 35 percent (n = 301) won and paid or won but did not pay (7 percent in the control group and the remaining 28 percent in the treatment groups).

As a strategy to identify whether there is a potential for a social interaction effect on WTP, the bid difference of participants "with interaction" was compared with the bid difference of those "without interaction." As shown in Table 7, there is no statistical difference between those who interacted and those who did not interact with others about the study in terms of their premiums for iron beans. Thus, the fact that control group participants stated higher WTP for all varieties is less likely due to a social interaction effect.

Nevertheless, a dummy variable was included, controlling for social interaction in the regression analysis presented later. Further, a probit model[1] was estimated, where whether a participant interacted with others is the dependent variable, while participant characteristics are explanatory variables. This probit regression shows that growing an improved

Table 7: Mean difference in WTP (in RWF), by social interaction among participants

Groups	No interaction	Interaction	t-test
Control only			
Premium for RIB	31.4 (104.1)	35.4 (86.3)	NS
Premium for WIB	−54.5 (111.6)	−35.1 (122.5)	NS
Treatment only			
Premium for RIB	71.4 (88.6)	70.4 (84.4)	NS
Premium for WIB	−36.2 (107.2)	−41.1 (96.9)	NS

	"WON"			"LOST"		
	No interaction	Interaction	t-test	No interaction	Interaction	t-test
Control only						
Premium for RIB	22.2 (121.5)	61.4 (81.6)	NS	38.5 (89.1)	17.5 (86.1)	NS
Premium for WIB	−59.4 (129.2)	−24.7 (151.5)	NS	−50.7 (97.2)	−42.2 (99.9)	NS
Treatment only						
Premium for RIB	82.2 (103.2)	62.7 (77.8)	NS	64.6 (77.6)	74.3 (87.6)	NS
Premium for WIB	−38.7 (124.5)	−44.1 (110.1)	NS	−34.6 (95.2)	−39.5 (89.7)	NS
All: control + treatment						
Premium for RIB	64.4 (111.8)	62.5 (78.2)	NS	58.0 (81.2)	65.0 (89.6)	NS
Premium for WIB	−44.8 (125.7)	-40.0 (119.3)	NS	−38.7 (95.7)	−40.0 (91.2)	NS

NS = not significant; () = standard deviation.

1 Not reported because of space constraints

variety (beta: 0.40, p: 0.007) and years of education (beta: 0.06, p: 0.001) are positively correlated with interacting with others during the survey. Moreover, it can also be expected that the further the survey progressed the more the potential for participants to interact with one another. Therefore, cross terms between the week dummy variables (week 4 and week 5) and the social interaction variable were included in the regression analysis.

4.2 Effect of Availability and Frequency of Nutrition Information

The results of regression models estimating the effects of information frame, and frequency on participant premiums for RIB and WIB are presented in Tables 8 and 9, respectively, allowing for comparison of premiums across treatments. Socioeconomic variables and cross terms are only included in cases where these variables are not strongly correlated, to avoid potential multicollinearity issues[2]. Note that cross terms between prior knowledge and education as well as between the social interaction variable, education and growing improved variety variable are not included due to collinearity. Models 1–4 are the OLS estimations, while model 5 is the interval-censored estimation. Robust standard errors[3] are reported for all models. Coefficients are compared across models, and models are also compared using R^2 as a measure of goodness-of-fit. For the interval-censored model, squared multiple correlations are computed (R^2 equivalent) between predicted and observed values of premium to be able to compare this model with the OLS estimations.

First, full models where socioeconomic characteristics hypothesized to influence the premium are controlled for having a higher R^2 than the basic model. For both RIB and WIB, full-sample models perform better than the partial-sample models; thus, the latter are not reported. Similarly, the differences between coefficients obtained in model 2 (without non-payment variable) and those obtained in model 3 (with non-payment variable) are not large, while an F-test comparing the two models is not significant in both varietal cases. Further, the coefficient on the non-payment variable is not significant. And even when the premium submitted by non-payment participants was modeled as interval censored (model 5), the differences in the coefficients are also not large. This suggests that non-payment has no important effect on participant premium for either the RIB or the WIB variety, as expected, since the difference in WTP has been modeled. Although it is expected that social interactions among participants during the survey may have a significant effect on their premium for iron bean variety, the results presented in model 4 suggest that this is not the case, which is consistent with the descriptive statistics discussed earlier. An F-test comparing models 3 and 4 is also not significant for both RIB and WIB. Since R^2 is not uniquely different across models 2–5 in Tables 8 and 9, we choose to discuss OLS model 4, which controls for all hypothesized covariates.

Regarding the treatment effect, the effect of information on participant premium for the RIB variety is discussed first. Model 4 in Table 8 shows that all information types have a positive and significant effect on participant premium for the RIB variety. Coefficients on these treatment variables show that the gain frame nutrition information when provided once resulted in a premium of about 23 RWF for RIB, while the loss frame nutrition information when also provided once resulted in about 22 RWF for the same variety (which is about 4 percent of the average market price for 1 kg of beans—i.e., 540 RWF). However, when the information is given three times, the gain frame resulted in a higher premium of about 38 RWF, while the loss frame information when given three times also resulted in a higher premium of about 39 RWF (about 7 percent of the average market price for 1 kg of beans). In the case of the WIB variety, model 4 in Table 9 shows that the nutrition information has a significant effect on participant premium for the variety relative to the local variety only when the information is provided three times. Providing the gain frame information three times resulted in a premium of about 26 RWF for WIB, while providing the loss frame information three times resulted in a higher premium of about 33 RWF for the same variety (about 5–6 percent of the average market price for 1 kg of beans).

To examine if the information frame and frequency have an impact on participant premium, we conducted some hypothesis testing comparing the coefficients, as shown in Table 10. The results presented in this table suggest that there is no significant difference between coefficients when gain frame and loss frame information is each given once (i.e., once versus once). Similarly, when this information is each given three times, there is no statistical difference in coefficients (i.e., three times versus three times). However, the results show that the frequency of providing the information is significant only for the loss frame information and only in the case of WIB variety. Although the coefficient on loss frame information when provided once is not significant in the case of WIB variety, this is significantly different at 5% level compared to the coefficient on loss frame information when provided three times. Thus, providing the loss frame information three times significantly increases participant premium for the WIB variety by about 84.4 percent (i.e., three times: 32.54 RWF versus once: 5.07 RWF).

2 Variance inflation factors obtained show that none of the variables included is strongly correlated (Maddala 2000).

3 The Breusch-Pagan/Cook-Weisberg test for heteroskedasticity is significant (for RIB only)

Table 8: Parameter Estimates from OLS Models for RIB

Dependent variable: *Difference in WTP for RIB relative to the local variety*

	Basic model	Full model	Full model with non-payment variable	Full model with social interaction variables	Interval-censored model
	1	2	3	4	5
T2 – Gain frame information/once	30.57*** (11.42)	22.20** (11.00)	21.62* (11.13)	22.73** (11.42)	23.01** (9.82)
T3 – Gain frame information/three times	45.97*** (12.30)	38.64*** (12.27)	38.30*** (12.38)	38.32*** (12.86)	35.92*** (10.42)
T4 – Loss frame information/once	31.53*** (11.52)	21.75* (11.12)	21.13* (11.44)	22.31* (11.57)	28.03*** (9.45)
T5 – Loss frame information/three times	48.00*** (12.32)	39.02*** (11.85)	38.55*** (12.01)	39.06*** (11.96)	34.25*** (10.21)
Per capita quantity of beans at home (kg)	–	-0.18 (0.13)	–0.18 (0.13)	–0.17 (0.14)	–0.18 (0.15)
Food insecurity (HFIAS)	–	0.31 (0.55)	0.33 (0.55)	0.29 (0.56)	0.07 (0.51)
Participant's household is self-sufficient (Yes = 1, No = 0)	–	0.59 (8.68)	0.71 (8.70)	1.45 (8.70)	2.55 (7.73)
Participant planned to buy beans on the day of BDM experiment	–	3.65 (9.56)	3.63 (9.58)	4.60 (9.46)	6.42 (7.44)
Aware of anemia	–	6.19 (6.67)	6.26 (6.63)	5.40 (6.77)	4.40 (5.72)
Male	–	–24.54*** (7.24)	–24.63*** (7.23)	–24.85*** (7.31)	–18.13*** (6.23)
Age	–	-0.15 (0.23)	–0.15 (0.23)	-0.13 (0.23)	-0.20 (0.21)
Education	–	0.84 (1.32)	0.82 (1.33)	0.85 (1.32)	0.79 (1.16)
Sensory liking relative to local	–	22.49*** (5.26)	22.49*** (5.26)	22.41*** (5.22)	13.71*** (3.43)
Grow improved variety (Yes = 1, No = 0)	–	–13.82 (8.43)	–14.05* (8.34)	–13.18 (8.45)	–6.10 (7.62)
Prior knowledge of iron beans (Yes = 1, No = 0)	–	23.79* (12.70)	23.97* (12.77)	22.29* (12.84)	13.93 (10.90)
Socially interacted with other participants (Yes = 1, No = 0)	–	–	–	3.54 (8.77)	4.47 (7.54)
Week 4 x socially interacted with others	–	–	–	–8.67 (11.20)	–6.50 (10.42)
Week 5 x socially interacted with others	–	–	–	8.26 (13.64)	9.36 (12.31)
Non-payment ("won but no payment + lost but would not have paid" = 1; otherwise, 0)	–	–	–2.64 (9.09)	–	–
Constant	33.07*** (8.57)	36.67** (18.55)	37.81** (19.07)	34.45* (18.94)	31.21* (16.66)
No. of observation	572	567	567	567	567
F statistic/ Chi^2	4.91	4.19	4.05	3.51	69.9
Prob > F/Prob> Chi^2	0.00	0.00	0.00	0.00	0.00
R-squared	0.04	0.13	0.13	0.13	0.12
Root mean square error	88.53	85.25	85.32	85.36	-
Log-pseudo likelihood	-	-	-	-	-2644.04

***1% significance level, **5% significance level, *10% significance level; () = robust standard error.

Table 9: Parameter estimates from OLS models for WIB

Dependent variable: *Difference in WTP for WIB relative to the local variety*

	Basic model	Full model	Full model with non-payment variable	Full model with social interaction variables	Interval-censored model
	1	2	3	4	5
T2 – Gain frame information/once	−0.50 (13.22)	6.15 (13.32)	6.91 (13.44)	8.86 (13.97)	1.14 (12.20)
T3 – Gain frame information/three times	18.90 (14.19)	22.03 (13.93)	22.48 (14.03)	25.91* (14.47)	17.92 (12.11)
T4 – Loss frame information/once	−3.84 (14.03)	2.48 (13.65)	3.31 (13.93)	5.07 (14.17)	-3.68 (12.23)
T5 – Loss frame information/three times	21.91 (15.28)	28.64* (14.64)	29.26* (14.88)	32.54** (15.34)	18.78 (12.87)
Per capita quantity of beans at home (kg)	–	−0.14 (0.14)	−0.13 (0.14)	−0.17 (0.14)	−0.22* (0.12)
Food insecurity (HFIAS)	–	0.58 (0.71)	0.56 (0.71)	0.67 (0.73)	0.59 (0.63)
Participant's household is self-sufficient (Yes = 1, No = 0)	–	11.65 (12.00)	11.48 (11.94)	10.93 (12.10)	0.58 (10.16)
Participant planned to buy beans on the day of BDM experiment	–	0.35 (9.71)	0.35 (9.72)	−1.26 (9.78)	−0.05 (8.36)
Aware of anemia	–	−1.10 (8.63)	−1.19 (8.64)	−0.57 (8.68)	2.59 (7.71)
Male	–	−5.48 (8.39)	−5.35 (8.42)	−5.15 (8.41)	−4.75 (7.36)
Age	–	0.12 (0.27)	0.12 (0.27)	0.09 (0.27)	-0.10 (0.24)
Education	–	2.26 (1.52)	2.29 (1.53)	2.32 (1.53)	1.44 (1.37)
Sensory liking relative to local	–	18.53*** (2.15)	18.46*** (2.16)	18.53*** (2.17)	16.88*** (1.88)
Grow improved variety (Yes = 1, No = 0)	–	−7.37 (10.30)	−7.04 (10.26)	−7.07 (10.29)	−2.55 (9.49)
Prior knowledge of iron beans (Yes = 1, No = 0)	–	−3.61 (16.39)	−3.84 (16.41)	−4.03 (16.55)	−1.52 (14.74)
Socially interacted with other participants (Yes = 1, No = 0)	–	–	–	−1.47 (11.32)	−2.65 (10.01)
Week 4 x socially interacted with others	–	–	–	−2.02 (14.46)	3.10 (13.19)
Week 5 x socially interacted with others	–	–	–	−17.14 (14.16)	−12.60 (12.96)
Non-payment ("won but no payment + lost but would not have paid" = 1; otherwise, 0)	–	–	3.57 (10.37)	–	–
Constant	−46.24*** (10.32)	−49.89** (23.78)	−51.49** (24.37)	−48.60** (24.31)	−28.87 (20.01)
No. of observation	572	567	567	567	567
F statistic/ Chi²	1.45	6.85	6.44	5.76	117.20
Prob > F/Prob> Chi²	0.22	0.00	0.00	0.00	0.00
R-squared	0.01	0.12	0.13	0.13	0.12
Root mean square error	104.74	99.90	99.98	100.01	-
Log-pseudolikelihood	-	-	-	-	-2712.66

***1% significance level, **5% significance level, *10% significance level; () = robust standard error.

These results suggest that while the frame of information provided does not matter, the frequency of providing the information does. Although this indicates that either gain or loss frame information can increase demand for both iron bean varieties, the fact that the more frequently provided loss frame information has the highest premium for WIB variety is consistent with the expectations that loss aversion could matter in participants' valuation of novel goods. Thus loss frame information is likely to be more cost-effective in increasing demand for WIB variety while either of the two information frames may be effective in promoting demand for the RIB variety.

4.3 Other Covariates

As expected, the coefficient on food insecurity variable is positive, while the coefficient on the quantity of beans participants had at home during the survey is negative. However, these coefficients are not significant (in the case of both varieties). Contrary to the expectation that participants' premium for the iron bean varieties would be driven by social interactions during the survey, the coefficients on the social interaction variable and its cross terms with week 4 or week 5 are not significant for both iron bean varieties. This result is consistent with the descriptive statistics discussed earlier and is plausible, since the difference in WTP has been modeled. Further, the result indicates that whether a participant's household grows improved varieties does not have a significant effect on their premium for either the RIB or the WIB variety. Meanwhile, prior knowledge of iron beans before the survey is significant at 10 percent level in the case of RIB variety while it is not significant in the case of WIB variety. The result suggests that those participants with prior knowledge of iron beans are willing to pay about 22 RWF more premium for the RIB variety.

However, consistent with expectations, the results show that participants' liking for the attributes of each of the iron bean varieties significantly increases their premium. Also, it is interesting to find that male participants have a lower premium, but this is only significant for the RIB variety. This is consistent, because women may have a better-informed assessment of the varieties, since they are usually responsible for market purchases and for cooking the beans for home consumption.

Table 10: F tests comparing coefficients in model 4

Comparison	Definition	F statistic
RIB variety		
T2 vs. T4	Effect of information frame (both given once)	0.00
T3 vs. T5	Effect of information frame (both given three times)	0.00
T2 vs. T3	Effect of frequency of providing gain frame information	1.80
T4 vs. T5	Effect of frequency of providing loss frame information	2.21
WIB variety		
T2 vs. T4	Effect of information frame (both given once)	0.09
T3 vs. T5	Effect of information frame (both given three times)	0.22
T2 vs. T3	Effect of frequency of providing gain frame information	1.85
T4 vs. T5	Effect of frequency of providing loss frame information	4.02**

**5% significance level

4. CONCLUSIONS AND POLICY IMPLICATIONS

This paper investigates consumer acceptance of two iron bean varieties (red and white) relative to a popular red mottled local variety in the rural areas of Rwanda's Northern Province. It examines consumers' evaluation of bean sensory attributes using hedonic rating and their willingness to pay (WTP) for the varieties using the Becker-DeGroot-Marshak (BDM) mechanism. The sensory evaluation was conducted in a home use setting. Previous research on consumer acceptance of biofortified foods has generally shown that information on the nutritional benefits of biofortified varieties yields a significant premium for these varieties compared with conventional food. We take this research forward by investigating the impact of how the information is framed (gain versus loss) and the frequency of providing the information on participants' WTP.

Without an information campaign about the nutritional benefits of iron bean varieties, the white iron bean (WIB) variety was assessed at a large discount (11 percent), compared with the local variety. In contrast, the red iron bean (RIB) variety captures a large premium (7 percent) in the absence of information about its nutritional benefits, revealing that it can compete favorably with the popular local variety in the absence of information. However, providing information about the nutritional benefits of iron bean varieties significantly increases the participant premium for the RIB variety and significantly lowers the participant discount for the WIB variety.

The results revealed no significant differences in the information frame effects (gain versus loss) on participant premium. However, the frequency of nutrition messaging matters. Toward the goal of maximizing the adoption and consumption of iron bean varieties in the rural areas, only the loss frame information has the potential of significantly increasing demand when provided three times. The fact that the effect of frequency of providing information is found only in the loss frame and not in the gain frame also suggests the existence of loss aversion in participants' demand for iron bean varieties, which is consistent with results found in the existing literature (Horowitz and McConnell 2002). This result also indicates that while providing the nutrition information can lead to a significant premium for the RIB variety regardless of the frequency, promoting the WIB variety will be costlier, since nutrition information significantly increases the premium for this variety only when provided three times. Meanwhile, the cooking time of this variety is liked the most; thus, other types of messaging emphasizing the preferred sensory attributes of this variety may assist its promotion in rural areas.

To ascertain that these results are consistent, various models of the participant premium estimated accounted for (1) non-payment effect, (2) social interaction effect, (3) selection bias, and (4) home inventory of beans.

The results suggest that the estimations are not driven by these factors. Investigation of the effects of participants' inability to make an out-of-pocket payment after "winning" in the experiment is a significant part of this analysis.

Although this has no effect on premium for iron bean varieties, the study data show that lack of payment and lack of intention to pay can increase participants' WTP by up to 18 percent. This is similar to Oparinde et al. (2014), who found a 24 percent increase in WTP due to a non-payment effect.

The present study and Oparinde et al. (2014) have demonstrated that it is feasible to conduct revealed preference-elicitation experiments in African countries in an out-of-pocket payment context, while avoiding the cash-in-hand effect bias introduced by participation fees, as noted in previous studies (Loureiro, Umberger, and Hine 2003; Corrigan and Rousu 2006; Morawetz, De Groote, and Kimenju 2011).

REFERENCES

Asare-Marfo, D., E. Birol, L. Katsvairo, J. D. Manirere, F. Maniriho, and D. Roy. 2011. "Farmer Choice of Bean Varieties in Rwanda: Lessons Learnt for HarvestPlus Delivery and Marketing Strategies." Unpublished project report. Washington, DC: International Food Policy Research Institute, HarvestPlus.

Asare-Marfo D., E. Birol, C. Gonzalez, M. Moursi, S. Perez, J. Schwarz, and M. Zeller. 2013. Prioritizing Countries for Biofortification Interventions Using Country-Level Data. HarvestPlus Working Paper No.11. Washington, DC: International Food Policy Research Institute, HarvestPlus.

Banerji, A., S. Chowdhury, H. De Groote, J. V. Meenakshi, J. Haleegoah, and M. Ewool. 2013. Using Elicitation Mechanisms to Estimate the Demand for Nutritious Maize: Evidence from Experiments in Rural Ghana. HarvestPlus Working Paper No. 10. Washington, DC: International Food Policy Research Institute, HarvestPlus.

Chowdhury, S., J. V. Meenakshi, K. Tomlins, and C. Owori. 2011. "Are Consumers Willing to Pay more for Biofortified Foods? Evidence from a Field Experiment in Uganda." American Journal of Agricultural Economics 93: 83–97.

CIAT. 2004. "Enhancing Farmers' Access to Seed of Improved Bean Varieties in Rwanda." Highlights, CIAT in Africa, No. 15, December.

Coates, J., A. Swindale, and P. Bilinsky. 2007. Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide. Vol. 3. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Corrigan, J. R., and M. Rousu. 2006. "The Effect of Initial Endowments in Experimental Auctions." American Journal of Agricultural Economics 88 (2): 448–457.

de Benoist, B., E. McLean, I. Egli, and M. Cogswell. 2008. Worldwide Prevalence of Anaemia 1993–2005: WHO Global Database on Anaemia. Geneva: World Health Organization.

De Groote, H., S. C. Kimenju, and U. B. Morawetz. 2011. "Estimating Consumer Willingness to Pay for Food Quality with Experimental Auctions: The Case of Yellow versus Fortified Maize Meal in Kenya", Agricultural Economics, 42: 1–16.

DHS (Demographic Health Survey). 2010. Rwanda Demographic and Health Survey, Final Report, National Institute of Statistics of Rwanda. http://dhsprogram.com/pubs/pdf/fr259/fr259.pdf

Ferris, R. S. B. 2002. Bean Sub-sector Market Survey: Rwanda. ATDT-CIAT/ISAR/IITA-FOODNET and PEARL Project—Rwanda. http://www.foodnet.cgiar.org/market/Rwanda/reports/maizereportATDT.pdf

Haas, J. D., S. Villalpando, S. Beebe, R. Glahn, T. Shamah, and E. Boy. 2011. "The Effect of Consuming Biofortified Beans on the Iron Status of Mexican School Children." The FASEB Journal 25 (March 17): 96.6.

Hartmann, W. R., and V. B. Viard. 2008. "Do Frequency Reward Programs Create Switching Costs?" Quantitative Marketing and Economics 6 (2): 109–237.

Horowitz, J. K., and K. E. McConnell. 2002. "A Review of WTA/WTP Studies." Journal of Environmental Economics and Management 44 (3): 426–447.

Kiria, C. G., H. Vermeulen, and H. De Groote. 2010. "Sensory Evaluation and Consumers' Willingness to Pay for Quality Protein Maize (QPM) Using Experimental Auctions in Rural Tanzania." 3rd International Conference of the African Association of Agricultural Economists, September 19–23, Cape Town, South Africa.

Kopalle, K. P., S. A. Neslin, B. Sun, Y. Sun, and V. Swaminathan. 2012. "The Joint Sales Impact of Frequency Reward and Customer Tier Components of Loyalty Programs." Marketing Science 31 (2): 216–235.

Loureiro, M. L., W. J. Umberger, and S. Hine. 2003. "Testing the Initial Endowment Effect in Experimental Auctions." Applied Economics Letters 10: 271–275.

Luna S., S. Villalpando, T. Shamah, E. Boy, and J. Haas. 2012. "Inflammation, Weight Status, and Iron Status in Mexican Children in a Randomized Controlled Iron-Biofortified Bean Feeding Trial." The FASEB Journal 26 (March 29):1031.15.

Lusk, J. L., and J. F. Shogren. 2007. Experimental Auctions: Methods and Applications in Economics and Marketing Research. Cambridge, England: Cambridge University Press.

Maddala, G. S. 2000. Introduction to Econometrics. 3rd edition. Upper Saddle River, NJ: Prentice-Hall.

Meenakshi, J. V., A. Banerji, V. Manyong, K. Tomlins, N. Mittal, and P. Hamukwala. 2012. "Using a Discrete Choice Experiment to Elicit the Demand for a Nutritious Food: Willingness to Pay for Orange Maize in Rural Zambia." Journal of Health Economics 31: 62–71.

Morawetz, U. B., H. De Groote, and S. C. Kimenju. 2011. "Improving the Use of Experimental Auctions in Africa: Theory and Evidence." Journal of Agricultural and Resource Economics 36 (2): 263–279.

NAS (National Agricultural Survey). 2008. Report of National Data Analysis. Kigali City: Republic of Rwanda, National Institute of Statistics of Rwanda.

Oparinde, A., A. Banerji, E. Birol, and P. Ilona. 2014. Information and Consumer Willingness to Pay for Biofortified Yellow Cassava: Evidence from Experimental Auctions in Nigeria. HarvestPlus Working Paper No. 13. Washington, DC: International Food Policy Research Institute, HarvestPlus.

Shogren, J. F., S. Cho, C. Koo, J. List, C. Park, P. Polo, and R. Wilhelmi. 2001. "Auction Mechanisms and the Measurement of WTP and WTA." Resource and Energy Economics 23 (2): 97–109.

Talsma, E. F., A. Melse-Boonstra, B. P. H. de Kok, G. N. K. Mbera, A. M. Mwangi, and I. D. Brouwer. 2013. "Biofortified Cassava with Pro-Vitamin A Is Sensory and Culturally Acceptable for Consumption by Primary School Children in Kenya." PLOS ONE 8 (9): 1–8.

Tomlins, K. I., J. Manful, J. Gayin, B. Kudjawu, and I. Tamakloe. 2007. "Study of Sensory Evaluation, Consumer Acceptability, Affordability and Market Price of Rice." Journal of the Science of Food and Agriculture 87: 1564–1575.

Viscusi, W. K., and J. Huber. 2012. "Reference-Dependent Valuations of Risk: Why Willingness-to-Accept Exceeds Willingness-to-Pay." Journal of Risk and Uncertainty 44: 19–44.

APPENDIX: RADIO MESSAGES

Radio Message (Gain Frame)

[Mother = Karine]

[Karine's neighbor = Female farmer = Marie]

Mother: Good evening, my neighbor Marie, welcome!

Farmer Neighbor: Hello, madam Karine. I have news for you. Do you know that when **you have** enough iron in your diet you will have physical strength and endurance and therefore will become tired less rapidly? **[EMPASIS ON THIS ASPECT OF THE MESSAGE]**

This means you will have optimal strength to undertake heavy physical activities (such as working in the field). When your children have enough iron in their diets they will perform better in school because their minds or brains will be able to focus better and pay more attention to school work.

You should be giving highiron beans to your children. This bean type has about 40 to 70 percent more iron than the local variety. It also grows well like any other popular variety. My family is already growing and consuming high-iron beans.

Farmer Neighbor: I am leaving for market now to buy some high-iron beans for my family. Bye-bye, madam Karine.

Radio Message (Loss Frame)

[Mother = Karine]

[Karine's neighbor = Female farmer = Marie]

Mother: Good evening my neighbor Marie, welcome!

Farmer Neighbor: Hello madam Karine. I have news for you. Do you know that: When you do not have enough iron in your diet, your body is also low in iron and you will feel tired and weak and you will not be able to withstand physical labor or exercise for as long as a healthy person can. [EMPHASIS ON THIS ASPECT OF THE MESSAGE]

This means you may be too weak to undertake heavy physical activities (such as working in the field). When your children do not have enough iron in their diets they will have reduced performance at school because their minds or brains will not be to pay attention and focus on school work.

You should be giving high iron beans to your children. This bean type contains iron and gives about 40 – 70% more iron than normal variety. It also grows well like any other popular variety. My family is already growing and consuming high iron beans.

Farmer Neighbor: I am leaving for market now to buy some high iron beans grains for my family. Bye bye madam Karine