Information and the trade-off between food safety and food security in rural markets: Experimental evidence from Malawi.

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Abstract

We implemented a clustered randomized control trial with experimental auctions among 1,098 rural households in Malawi to evaluate whether providing training about food safety increased demand for safe groundnut. We measured the impact of training on demand for observable and unobservable quality, at harvest and in the lean season. We found that the control group who was not trained valued observable quality only. At harvest, both trained and untrained consumers placed statistically equal premiums on unobservable quality. However, in the lean season, untrained consumers' premium for unobservable quality disappeared, while trained consumers' premium for unobservable quality increased.

Keywords: randomized controlled trial, experimental auction, product quality, aflatoxins, groundnut, sub-Saharan Africa.

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Introduction

Many rural food markets in the developing world are characterized by informality (defined by a lack of enforceable quality grades and standards), along with pronounced seasonality. Seasonality takes the form of one (or at most two) harvests per calendar year, creating a challenge for smallholder farm households to maintain food quantity and quality until the next harvest. Food availability and quality are highest at harvest while prices are lowest. Conversely, later in the year – during the "lean" season – quantity and quality of food are low and prices are high. However, many smallholder farmers fail to take advantage of this clear arbitrage opportunity (e.g., storing at harvest for sale later in the year), a phenomenon labeled "sell low and buy high" (Burke et al., 2019). This is partially due to storage issues creating physical losses to stored grain (Aggarwal et al., 2018; Kadjo et al., 2016; Omotilewa et al., 2018), to cash and liquidity constraints (Basu & Wong, 2015; Burke et al., 2019; Channa et al., 2021; Stephens & Barrett, 2011), and to behavioral and social challenges including commitment issues, impatience, self-control and social pressure in rural communities to share (Ashraf et al., 2006; Baland et al., 2011; Basu, 2014; Brune et al., 2011).

To date the literature on household behavior under seasonality has not considered how seasonality affects demand for food quality in times of plenty (at harvest) and times of scarcity (during the lean season). Understanding the tradeoff between food security and food safety is essential because functioning markets depend on a consistent supply of quality grain (Hodges et al., 2011). Households' grain sale and purchase behaviors are affected by both dimensions. It is also unclear whether and how interventions to improve food safety impact the tradeoff between food quality and quantity that limited-resource households inevitably have to make to endure the lean season.

Many rural markets are dominated by numerous small-scale producers and traders who typically operate without formal business registration. This makes enforcement and monitoring of quality standards in these markets difficult and expensive (Grace et al., 2015; Hoffmann et al., 2019; Roesel & Grace, 2015). This lack of regulation and coordination can have important negative consequences on human health (WHO, 2015). Given the unobservability of many food quality attributes (for example, presence of chemical and biological contaminants), producers and traders in these informal markets have little or no incentive to invest in grain quality, giving rise to a "lemons market" in which low quality products dominate (Akerlof, 1970).

We implemented a clustered randomized control trial (RCT) with 1,098 rural households in central Malawi to evaluate whether randomly providing information in the form of training about food safety increased consumers' demand for safe groundnut (peanuts). We used Becker-Degroot-Marshack (BDM) auctions to elicit consumers' willingness to pay (WTP) for three quality grades of groundnuts: (i) "unsorted grade," for which broken or damaged nuts were not sorted out, and without a food safety information label, as would be commonly sold in rural markets; (ii) "sorted grade," which included visibly sorted groundnuts with only undamaged nuts, and without a food safety information label; and (iii) "labeled grade," constituted of visibly sorted groundnuts with only undamaged nuts, and with a food safety label. The auctions for groundnuts of the three different levels of quality were conducted in both the harvest and lean seasons with the same households.[2]

Our main research objective is to estimate the trade-off between food safety and food security among rural consumers, during times of plenty and during times of scarcity. In addition, we evaluated whether training on food safety, along with labels that made food safety attributes observable to consumers, increased their demand for higher-quality/safe grain across the year. We also calculated whether the food safety label created a separating equilibrium among consumers, by which demand for safe food exceeded the cost of testing and labeling it as such.

The food safety threat we tested and provided information about in this study were aflatoxins. They are poisons produced by fungi present in the soil that affect staple and cash crops such as maize, rice, sorghum, cassava, groundnut and millet. Aflatoxins thrive in the field, and in storage if grains are not dried and stored properly. These toxins pose a serious health risk globally, including liver and esophagus cancers, stunting, malnutrition and immunodeficiency (Khlangwiset et al., 2011). Furthermore, aflatoxins are unobservable to consumers in rural markets, because they are tasteless, colorless, and odorless (NTP (National Toxicology Program), 2019), and testing does not exist in these markets. Therefore, if consumers learn about and value the unobservable attributes of aflatoxins-safe groundnuts then providing training about aflatoxins food safety could make the issue more salient.

In this study, we test the extent to which people who have been trained about aflatoxins and shown groundnuts for sale with a label stating that they are "aflatoxin-free" are willing to pay a premium for the labelled food. The label was supported by a certificate from a certified lab where the groundnuts were tested. If the premium they pay is large enough to cover the cost of testing and labeling it could incentivize producers to sell higher-quality grain at a premium price. Conversely, without training and labeling groundnuts "aflatoxin-free," the seller (either a producer or a trader) will have more information than the perspective buyer about aflatoxin levels because the seller has owned the grain longer and knows more about the conditions under which the crop was produced, harvested, dried, stored etc. Without a way to identify safe from unsafe food, the situation will devolve into a "lemons market" where low quality permeates.

This article contributes to the literature in three main ways. First, to our knowledge we are the first to empirically estimate the extent of the trade-off between food security and food safety that many rural consumers make, at harvest and in the lean season. In doing so we contribute to the literature on consumption and income seasonality among limited-resource households. Previous studies have shown that many farmers sell a large share of their crops at harvest and purchase the same crop for food during the lean season. This "sell low and buy high" phenomenon threatens food security and prevents farmers from take advantage of arbitrage opportunities (Burke et al., 2019). Improved storage technology increases quantity stored at harvest, length of storage, and income (Aggarwal et al., 2018; Chegere et al., 2021; Nindi et al., 2021). We add to this important literature by incorporating the food quality and safety dimensions to household consumption and income decisions across seasons. To our knowledge the only study to consider demand for food quality in rural markets at harvest and lean seasons focused on observable attributes such as insect damage and mold (Kadjo et al., 2016). In doing so, our paper provides empirical evidence of the effect of scarcity on consumers' demand for safe food – a largely unobservable attribute – and provides valuable information on the food quantity vs. food quality tradeoff that consumers make.

Second, to our knowledge we are the first study to experimentally disentangle observable and unobservable premiums in consumers' willingness to pay for food safety in both the harvest and lean season. Most previous studies of consumers' WTP for grain quality have measured demand for observable quality (Kadjo et al., 2016) or unobservable quality (Hoffmann & Gatobu, 2014; Prieto et al., 2021), but not both. In a correlational analysis of maize samples from Kenyan mills, Hoffmann, Mutiga, et al. (2021) found that only observable quality was priced at a premium, but that unobservable quality (safety from aflatoxin contamination) was not. De Groote et al. (2016) compared maize of three quality grades: visibly moldy, visibly clean but unlabeled, and visibly clean and labeled "aflatoxin-safe." Our study builds upon De Groote et al. (2016) by estimating how demand for different quality grades of grain changed across the year. Importantly we tested demand for different grades of groundnuts during the lean season, when the food quantity vs. food quality trade-off was most relevant. In addition, we constructed a simple benefit-cost calculation to estimate whether the premiums consumers were willing to pay for both groundnuts of high observable quality and high unobservable quality during the lean season were large enough to cover 1) the cost of sorting groundnuts to create a separating equilibrium on observable quality and 2) the cost of testing groundnuts for aflatoxins to create a separating equilibrium on unobservable quality. These findings are important for understanding the surplus or shortfall in profit for a private company to engage in sorting and testing and were the public sector may need to step in to bridge the profitability gap.

Third, we estimate the causal impact of providing training on aflatoxins and their dangers on farmers' WTP for various quality grades, using a randomized controlled trial. Providing information on aflatoxins has been shown to increase demand for maize flour in Kenya (Hoffmann, Moser, et al., 2021), particularly when an aflatoxins-free certification was provided (De Grotte et al. 2016; Kariuki & Hoffmann, 2019). Our study randomly divided participants into a group that was trained, receiving information about aflatoxins at harvest and a control group that was not trained. Since we only trained participants at harvest and not six months later during the lean season, we were able to test the saliency and longer-term impact of the food safety training among rural consumers. This provides important behavioral insights and has implications for the cost-effectiveness of awareness building campaigns.[3,4]

[3] We only provided food safety training to treated households at harvest and did not repeat the training in the lean season. to make the intervention more realistic of a true mass-extension campaign that would likely only train the same households once. Though some members of the treatment group may have forgotten about the information after six months, our estimates can be viewed as a lower-bound impact from providing food safety information to this population.

[4] We also focus on groundnuts rather than maize. Groundnuts are an interesting crop to study for this application because they are both a cash and a staple crop for many smallholder farmers in Malawi and elsewhere in SSA. Furthermore, smallholder farmers' sale of groundnuts can be limited by their inability to meet stringent aflatoxin restrictions on international markets. In turn, these constraints could influence their demand for groundnut quality and their response to information in different ways from a staple crop like maize.

Our results indicated that the information provided by the food safety training helped increase consumers' demand for both observable and unobservable grain quality attributes. Consumers' willingness to pay for observable quality was higher than for unobservable quality, and only consumers who had been trained on aflatoxin contamination were willing to pay for unobservable quality (a premium of about 13 percent of the local market price). Receiving training about aflatoxins increased consumers' demand for observable quality in the harvest season by 22 percent of the market price; and for unobservable quality by 16 percent of the market price in the lean season when food was scarce.

These results suggest that providing training may incentivize consumers to increase the relative importance they place on food safety during the lean season, compared to those without training who may be inclined to prioritize food security (availability) during times of scarcity. This suggests that government investment in aflatoxin awareness and training campaigns could facilitate a sustainable supply of higher-quality safe food in rural markets.

Study Setting, Sample, Experimental Design and Auction Procedures

Background

Groundnuts are an important crop in Malawi, accounting for about 10 percent of the average total cultivated area between 2007 and 2017 (FAOSTAT, 2020). In the past 10 years Malawi has been among the top 14 producers of groundnuts in Africa (ranked number 2 in Southern and Eastern Africa), producing an average of about 334,000 tons of unshelled groundnuts per year (FAOSTAT, 2019). The crop is particularly important to smallholder farmers, who account for about 90 percent of its total production (Derlagen & Phiri, 2019) and from which they derive over 20 percent of their agricultural income (Beghin et al., 2004).

About 60 percent of the total production of groundnut in Malawi is sold and consumed domestically (Derlagen & Phiri, 2019), so the crop is an important source of dietary protein, fats and vitamins for the farmers who grow them and for other rural households. A study by Gelli et al. (2020) found that legumes including groundnut contributed about 8 percent of the average equivalent daily food consumption per adult in Malawi.

Although exports continue to be important target markets for Malawi's groundnut sector, the export quantities have significantly declined compared to 20 to 50 year ago (FAOSTAT, 2019).

This is due in part to the introduction of aflatoxins regulations in several potential export countries, including a maximum aflatoxin requirement of 4 μg/kg for groundnut in the European Union (European Commission, 2006). As such, domestic markets especially the under-regulated informal grain markets have become important targets for groundnut that fail to meet export markets' food safety requirements (Edelman & Aberman, 2015). Aflatoxins contamination in groundnut and groundnut products remains a major problem in Malawi and most of SSA (Monyo et al., 2012; Ncube & Maphosa, 2020; Njoroge et al., 2017). In Zambia, Njoroge et al. (2016) reported that 80% of brands of peanut butter tested in 2013 had levels of aflatoxins B1 higher than 20 μg/kg; several brands source peanuts from neighboring countries including Malawi. None of the eight brands tested over three years averaged aflatoxins B1 levels below 20 μg/kg. As a result, informal markets are likely to be characterized by the undersupply of aflatoxins-safe grain. Matumba et al. (2015), for example, found that samples of raw groundnut in Malawi destined to local informal markets had a mean aflatoxins level of 122 μg/kg, well above the European Union requirement of 4 μg/kg, but samples of similar groundnut destined to the export market had aflatoxins levels of 2.6 μg/kg on average. We are not aware of published data comparing aflatoxins levels in groundnut at harvest and in the lean seasons, but it is known that the quality of grain (including prevalence of molds and aflatoxins) in SSA markets also diminishes in the dry lean season due to lack of appropriate storage technologies (Kadjo et al., 2016).

In Malawi, the supply of most agricultural commodities including groundnuts are dependent on rain-fed production. Increases in commodity supply during the harvest season often put downward pressure on prices such that grain prices tend to reach their lowest levels at harvest. However, due to scarcity, prices tend to recover in the lean season often reaching their highest levels at the peak of the season which is typically between 6 to 8 months after harvest. This normally creates large seasonal variations in prices (Gilbert et al., 2017; Kaminski & Christiaensen, 2014). Grain quality also varies across seasons. This is due to post-harvest losses incurred during storage and these losses increase the longer the grain is stored (Kadjo et al., 2016; Kaminski & Christiaensen, 2014). Therefore, seasonality in commodity supply affects both the quality and price of groundnuts over the year.

Sampling and experimental design

Our sample included 1,098 farmers from Mchinji district in central Malawi, the major groundnut-producing area in the country (see Study area in Figure 1). Farmers were randomly selected from a list of members of the National Smallholder Farmers' Association of Malawi (NASFAM), a farmer-based organization that has over 43 associations across the country. Each NASFAM association had sub-units at the community level, called Group Action Centers (GACs). GACs were typically about 10 to 35 kilometers apart. A single NASFAM association counted 21 GACs (or communities) on average, with each GAC having an average of about 15 farmer clubs. A club was made of 10 farmers who resided within the same village; villages were typically 1-5 kilometers apart from each other. We targeted two associations for the study, and we randomly selected 16 GACs from each association to form the study sample. Within each of the 32 GACs, we randomly selected 25 farmers, subject to the condition that at least 2 (and at most 5) farmers were selected in each club. The resulting initial sample included 830 farmers, who participated in the auctions twice: in the harvest and lean seasons. To these, we added 268 randomly-sampled new farmers in the lean season auction, to test for possible learning effects arising from the bulk of our sample bidding in the same auction twice.[5] These additional participants were also randomly selected from the same GACs and clubs as other participants (i.e., they belonged to the same clusters as other participants).

[Insert Figure 1 here]

Participants were randomly assigned to treatment (received training about aflatoxins) or control (did not receive training about aflatoxins). We assigned treatment at the GAC level to avoid potential information spillover across members in clubs (or villages) within the same GAC. This arrangement also ensured cost-effective administration of the study activities. Although GACs are

[5] Power calculations used baseline data from another study involving the same households, implemented in 2018 (Nindi et al., 2021), to get an estimate of mean and standard deviation of groundnut purchase prices for the harvest and lean season. These data indicated an intra-cluster correlation coefficient within GAC of 0.02. Calculations used 80 percent power and 95 percent confidence intervals. The calculations suggested that we could sample 32 total clusters (GACs) including 23 farmers per cluster to ensure a small-to-medium effect size (Cohen, 1988). These calculations gave us a minimum detectable effect (MDE) of 0.32 standard deviations between treated and control households. Our sample included 830 participants in the harvest season auction, and 1,013 participants in the lean season auction (745 repeated study participants + 268 new participants in the lean season). In total 85 households who were surveyed at harvest could not be found in the lean season (this is discussed in detail in the attrition sub-section below).

far enough apart to limit contamination, GACs that fall within the same association are generally similar in terms of member demographics.

The information provided to treatment group participants through the training included i) facts about aflatoxins, ii) the crops they affect, iii) the way they affect crops, iv) the health and economic effects of aflatoxins, and v) how to avoid or reduce aflatoxin contamination. The training script is provided in Appendix A. In the second round of the auction, during the lean season, participants in the treatment group were not given the aflatoxin training again. However, the new participants in the lean season were given the same training as the original treatment group received at harvest. Participants in the control group were provided with the training at the end of the study, after completion of all research activities.

Auction procedures

We elicited farmers' WTP for grain quality with incentive-compatible, revealed preference auctions using the Becker-Degroot-Marschak (BDM) mechanism (Becker et al., 1964). The BDM has been commonly applied in field experiments in developing countries (De Groote et al., 2016; Prieto et al., 2021). BDM auctions provide revealed preference estimates because participants bid real money and actually purchase the item. In our setting, because participants bid on three quality grades of groundnuts, one of their three bids was randomly selected as a binding bid that they purchased.

Participants were first oriented about the BDM goals and procedures, then went through two practice rounds with sweets to ensure they understood the process as well as understood that strategic bidding behavior was not beneficial. All the three groundnut quality grades were auctioned in one-kilogram units, and participants were allowed to inspect the groundnuts before bidding. They bid on the three quality grades of groundnut in random order. Once they bid for all the grades, the enumerator rolled a die in the presence of the participant to determine which of the three grades of groundnut was the binding bid. The participants then drew a paper from a bag that had uniformly distributed numbers around the median market price in each village, as reported by NASFAM farmers. Participants paid the random price they drew, if that price was below the price that they bid. We used their bid value as their WTP in all analyses. Everyone was given a fixed participation fee at the start of the survey to eliminate liquidity constraints that could limit participation and bias their WTP.

The auction was implemented twice, first during the harvest season in June 2019 when farmers had abundant stocks of grain. We purchased all groundnuts used in the auction from a single trader during the 2019 harvest in order to reduce heterogeneity in grain attributes. Appendix B shows pictures of the three quality grades used in the auctions. For the auction implemented in the lean season, we used the same grain that was purchased during the harvest season and stored it in hermetic (airtight) bags to ensure minimal variation in grain quality over the months between harvest and lean season (Baributsa et al., 2017). Aflatoxin testing of groundnuts was done by a laboratory in Malawi's capital (Appendix C). The aflatoxin-safe certificate was shown to participants when they were presented with the "labeled" quality grade and asked to bid. All groundnuts used in the auctions came from the sample with the aflatoxin level of 2.1 ppb (below the 15 ppb limit in Malawi and the 4 ppb limit in the European Union). Exact aflatoxin levels were not mentioned when presenting samples of groundnut to participants.

Analytical Approach

Empirical models

Our analyses proceeded in four steps. First we used data from the control group who was not trained with information on aflatoxins to estimate observable and unobservable quality premiums. The untrained control group is representative of the general population of rural consumers in Malawi who have very little knowledge about food safety. We regressed WTPs in the control group on three quality grades of groundnuts as follows:

$$WTP_{ijt} = \beta_0 + \beta_1 S_{ijt} + \beta_2 L_{ijt} + \beta_3 T_{it} + \beta_4 X_i + \varepsilon_{ijt} \qquad (1)$$

In equation (1), i indexes individual participants, j indexes groundnut quality grades, and t indexes the time when the bid was placed (ie: harvest or lean season). WTP is the bid value in Malawi Kwacha per kilogram of groundnut (MK/kg). S_{it}, L_{it} are binary variables equal to one if the grade of groundnut on which individual i bid was sorted (S_{it}), or sorted and labeled as aflatoxin safe (L_{it}), and zero otherwise. The unsorted groundnut grade is the omitted quality grade. Coefficient $\widehat{\beta_1}$ measures the observable quality premium, and the difference ($\widehat{\beta_2} - \widehat{\beta_1}$) measures the unobservable quality premium. Variable T_{it} is a binary variable equal to one if the bid was recorded in the lean season, and equal to zero if the bid was recorded in the harvest season. Vector

X_i contains baseline participants characteristics, including the participants' baseline aflatoxin knowledge score (range: 0-10) and the number of years that the participant's household has been a member in NASFAM (range: 0-30). The former is included because the randomization was imbalanced with respect to baseline aflatoxin knowledge (p=0.030; Appendix D, described below), and the latter is included because it was correlated with the likelihood of attrition between the harvest and lean seasons (p=0.002; Appendix E, described below). We present all analyses with and without vector X_i; results are nearly identical. Last, ε_{ijt} is the error term. Standard errors were clustered at the GAC level, which is the level of randomization of the information treatment; results are similar when clustering at the household level (see Appendix F).[6]

Next, to estimate the impact of the food safety training on WTP for groundnut quality, we implement the following regression on our full sample:

$$WTP_{ijt} = \alpha_0 + \alpha_1 S_{ijt} + \alpha_2 L_{ijt} + \alpha_3 I_{it} + \alpha_4 I_{it} * S_{ijt} + \alpha_5 I_{it} * L_{ijt} + \alpha_6 T_{it} + \alpha_7 X_i + \mu_{ijt} \quad (2)$$

where the subscripts, and variables WTP, S, L, T, X, are as described for equation (1). I is a binary variable equal to one if the participant was provided information/training about aflatoxins and their dangers before bidding (treatment group), and equal to zero if the participant was not trained (control group). The error term is μ_{ijt}. The observable quality premium for uninformed/untrained participants is estimated by $\widehat{\alpha_1}$, and the unobservable quality premium for uninformed/untrained participants is $(\widehat{\alpha_2} - \widehat{\alpha_1})$. The observable quality premium for informed/trained participants is $(\widehat{\alpha_1} + \widehat{\alpha_4})$, and the unobservable quality premium for informed/trained participants is estimated by the expression $(\widehat{\alpha_2} + \widehat{\alpha_5} - \widehat{\alpha_1} - \widehat{\alpha_4})$.

Third, to estimate the impact of food scarcity on the quality premiums for the control group only (representing the general population), we estimated a modified versions of equation (2) in which I_{it} is omitted and replaced by T_{it}, including its interaction with the two grade variables.

Finally, to measure the impact of information on observable and unobservable quality premiums between seasons, we estimated equation (2) without variable the T_{it} but separately for bids in the harvest season and in the lean season. This model was estimated using the full sample.

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[6] We did not use the fixed effects estimator in these analyses because it would drop some variables of interest including information training treatment and quality grade variables. In addition, the study was implemented across a six months period, so most of household characteristics (i.e. age, education landholding, etc) did not change, so the correlated random effects estimator was also not applicable.

Randomization balance checks

To estimate the balance of randomization, we used a probit estimator to model whether household characteristics were balanced across the treatment and control groups. Appendix D presents the results. The Chi-squared test of joint significance of all the covariates in the model suggested that the treatment assignment was not perfectly balanced (χ^2=31.8, p=0.046). However, only one variable showed a statistically significant imbalance: participants who had a higher previous knowledge of aflatoxins were 1.8 percentage points more likely to have been assigned to the treatment group (p=0.030). Though the magnitude of this difference is very small given that the mean aflatoxin awareness score was just 3.1 out of 10, in order to control for the possible effect of this imbalance, we present all results with and without this covariate included in regression models (in vector X_i); results were unaffected.

Attrition

WTP for the three grades of groundnut quality for each participant was measured twice, once at harvest and once in the lean season. In June 2019, during harvest, we surveyed and conducted the auction with 830 farmers. In January 2020, at the height of the lean season, we conducted a follow-up survey and a second auction with the same farmers. Of the 830 farmers surveyed at harvest, we could not locate 253 participants for the lean season survey and auctions (124 in the treatment group and 129 in the control group). In such cases, we aimed to survey another member of the household, and measured the new member's willingness to pay for the three groundnut quality grades. This effort was successful for 168 households, from whom we were able to collect lean season data. As a result, 85 households truly attrited between harvest and lean seasons; 50 of them were in the treatment group and 35 in the control group.

In order to estimate the possibility of bias from attrition being correlated with treatment assignment, we regressed a binary indicator of an individual or household being an attriter (1=could not be found for the lean season survey; 0=completed the lean season survey) on the treatment indicator and the set of baseline household characteristics included in the summary statistics table and the randomization balance test. Coefficient estimates showed that neither individual-level nor household-level attrition were correlated with random assignment (Appendices E and G). This suggests that our subsequent results remained consistent due to attrition although the missing households reduce the statistical power and perhaps the external validity of our results (Özler, 2017). At the individual level, years of schooling, gender, landholding, years as a NASFAM member, and members of the Chioshya NASFAM association were associated with the likelihood that a specific individual was not available to answer the survey and bid in the lean season. However, only one household characteristic was correlated with household attrition: years as a NASFAM member (p=0.002).

We addressed attrition in three ways. First, we ran all regressions with and without a control variable for years as a NASFAM member, the variable consistently associated with household-level attrition. All results were robust to the inclusion of this variable. Second, we re-estimated our main table with years of schooling, gender, landholding, and members of the Chioshya NASFAM Association included in the regression (Appendix H). Again, these results were nearly identical to our main results. Last, we re-estimate our main table on the sub-sample of individuals who were included in both the harvest and lean seasons, which excluded the respondents where different household members were surveyed in harvest and lean seasons (Appendix I).[7] Coefficient magnitudes and levels of statistical significance were similar to those in the main table. In summary, attrition – at the individual and household levels – did not impact our estimates.

Learning effects

Because most farmers in our sample were surveyed twice and bid twice on the same quality grades of groundnuts, learning may have occurred between harvest and lean seasons activities – about both aflatoxin and auction procedures – and may bias our measures of impacts and our comparisons across seasons. We tested for possible learning effects by re-estimating our main model with a binary variable equal to one if the household who bid in the harvest season also bid in the lean season, and zero if the household attrited between waves or was added to the lean season survey. Appendix L shows that coefficient signs, magnitudes, and statistical significance are the same as in the main estimates. Results are similar if we define the variable based on a farmer (rather than any household member) having participated in both waves (Appendix M).

[7] In Appendix J we also estimate a triple interaction model to compare coefficients from our main model (Table 6) across seasons. Appendix K shows this model estimated with only individuals were included in both the harvest and lean seasons; results are similar.

Summary statistics

Table 1 presents mean values of WTP for various quality grades, in Malawi Kwacha per kg (MK/kg; US$1=MK750 at the time of the study). At baseline (harvest season), the average WTP was MK233/kg for unsorted groundnuts, MK313/kg for sorted groundnuts, and MK334/kg for labeled groundnut grades. For all quality grades, the average WTP in the lean season was about 40 percent higher than that in the harvest season.

[Insert Table 1 here]

Table 2 shows characteristics of participants and their households. Before any aflatoxins information was shared with participants, they knew the correct answer to 3.1 out of 10 questions about aflatoxins, on average (the full list of questions is provided in Appendix N).[8] Only 39 percent of participants knew the answer to 5 or more questions. On average, participants were middle-aged (39 years), roughly equally divided between men and women (46 percent men), had received a primary school education (5.8 years of schooling), and owned 3.5 acres of land. Participants were food insecure for 1.5 months in the previous 12 months on average, and 74 percent of households reported being food insecure for at least one month.

[Insert Table 2 here]

Results

WTP for observable and unobservable quality attributes

Table 3 presents our base model, described in equation (1), for the sub-sample of uninformed consumers. Results represent demand for quality (aggregated across seasons) in a "normal" setting in rural markets, absent any information or training about the dangers of aflatoxins. They indicate that, on average, typical consumers value observable quality, but not unobservable quality. Auction participants in the control group were willing to pay MK82/kg more for the sorted grade of groundnut (19 percent of the local market price), on average, than for the unsorted grade ($p<0.001$). Auction participants in the control group were not willing to pay more for the labeled

[8] It is possible that some questions about aflatoxins could have primed respondents to the importance of aflatoxins and potential price seasonality. However, this would have only affected the control group since the treated group was trained with this information as part of the intervention. As a result, any priming of the control group would have increased their relative WTP and attenuated the results.

grade, on average, than for the sorted grade (coefficients indicate an unobservable quality premium of MK7, or 1.6 percent of market price; p=0.109). These numbers are averages over the harvest and lean seasons, when legume prices are markedly different. Analyzing bids in each season separately shows the same results (Appendix O).

[Insert Table 3 here]

Impact of information on quality premiums

Figure 2 shows three key impacts of training on the quality premiums (Table 4 presents the coefficients from equation (2), upon which Figure 2 is built). First, providing information about food safety through training increased consumers' quality premiums, for both observable and unobservable quality. The observable quality premium was MK34/kg higher for informed/trained participants than it was for uninformed/untrained participants (MK116 and MK82, respectively); the difference was statistically significant (F=31, p<0.001). The unobservable quality premium was MK55/kg higher for informed/trained participants than uninformed/untrained participants (MK62 and MK7, respectively); the difference was statistically significant (F=51, p<0.001).

Second, the higher observable quality premium for informed/trained participants stems from their discounting of low-quality (unsorted) groundnuts rather than placing a premium on sorted groundnuts. WTP for sorted groundnuts was statistically equal between informed/trained and uninformed/untrained groups, but WTP for unsorted groundnuts was MK26/kg lower for informed/trained participants (p<0.001). Finally, uninformed/untrained participants were not willing to pay a premium for unobservable quality. Regression coefficients estimated a MK7/kg premium for unobservable quality among uninformed/untrained participants, but this estimate was not statistically significant (p=0.093).

[Insert Figure 2 here] [Insert Table 4 here]

Food safety and food security trade-off

To evaluate the presence of possible trade-offs between food safety and food security, we estimated the effect of food scarcity on uninformed/untrained consumers' observable and unobservable quality premiums. We did this by interacting the two grade variables in equation (2) with variable T_{it}, a binary variable equal to one for bids made in the lean season and zero for bids made in the harvest season, on the sub-sample of uninformed/untrained participants only.

Results shows that uninformed/untrained participants placed a premium on observable quality in both harvest and lean seasons (MK50/kg and MK107/kg, $p<0.001$ and $p<0.001$; Table 5). The value of this premium was much higher in the lean season, when quantities are scarcer, than in the harvest season, even when measured in percentage of the unsorted groundnut grade to account for generally higher prices in the lean season: the observable quality premium was about 20 percent of the lower-quality grade in the harvest season, and 32 percent in the lean season.

Our data also show that uninformed/untrained participants were not willing to pay for unobservable quality in either season. At harvest, uninformed/untrained participants were willing to pay a premium for unobservable quality of about MK12/kg, on average, or about 5 percent of the market price of groundnut, and this was marginally statistically significant ($p=0.061$). However, during the lean season auction this possible premium completely disappeared: the estimated average unobservable quality premium was MK2/kg, equivalent to 0.6% of the market price of groundnut in the lean season ($p=0.507$).

[Insert Table 5 here]

Impact of information on quality premiums, by level of food scarcity

The level of food abundance or scarcity could influence how providing training about aflatoxin affects consumers' WTP for both observable and unobservable grain quality. We addressed this question by estimating equation (2) separately for the harvest and the lean seasons.[9] Figure 3 and column 1-2 of Table 6 show the impact of training on willingness to pay and quality premiums at harvest.

At harvest, results mirrored the estimates of the impacts of training on the observable quality premium: larger premium for informed participants than uninformed participants (i.e. MK116/kg versus MK50/kg). We also found that both informed/trained and uninformed/untrained participants placed a premium on unobservable quality. However, the amounts of these premiums

[9] A regression in which a binary variable indicating the lean season is interacted with quality grades and information/training (grade * information * lean), and the associated comparisons of WTPs across harvest and lean seasons, show that differences across seasons are all statistically significant (Appendix M). We present estimates for each season separately for clarity.

were not statistically different from each other at harvest. That is, informed/trained participants were willing to pay MK29/kg more for unobservable quality, compared to MK12/kg for uninformed/untrained participants. The MK17/kg difference was not statistically significant (F=2.5, p=0.127). The lack of statistical difference could have been because the informed/trained participants believed that the unobservable quality was high at harvest since the groundnuts were freshly harvested and the uninformed/untrained participants were not aware of the unobservable quality issue in the first place on average.

[Insert Figure 3 here]

In the lean season, the impact of training on participants' willingness to pay and quality premiums differed noticeably from the harvest season (see Figure 4 and columns 3-4 of Table 6 which show the impact of training on WTP and quality premiums in the lean season). First, although both the trained and untrained participants placed large premiums for observable quality, their observable quality premiums were not significantly different from each other (MK116/kg for the informed/trained versus MK107/kg for the uninformed/untrained; F=1.5, p=0.228). Estimates of the quality premium in percentage of the average willingness to pay for unsorted quality grade in each season, which adjusts for the mean difference in WTP across seasons, tell the same story (MK116/kg and MK107/kg represented 35 percent and 32 percent of the average willingness to pay for unsorted quality grade in each season).

Second, unlike the harvest season where the unobservable quality premium was not statistically different for informed/trained and uninformed/untrained participants (difference in premiums=MK17/kg, p=0.127), in the lean season, the impact of informing participants through training was large and statistically significant. This was because uninformed/untrained participants exhibited no premium for unobservable quality (MK=2/kg or 0.6 percent of the unsorted WTP in the lean season, p=0.494). However, informed/trained participants were willing to pay a premium of MK90/kg (27 percent of the unsorted WTP in the lean season, p<0.001) for groundnut of guaranteed unobservable quality. The difference was statistically significant (p<0.001).

[Insert Table 6 here] [Insert Figure 4 here]

To estimate the importance of household-level food scarcity, we analyzed the impact of information in the lean season, on sub-samples of households with different proxies for food scarcity. We used two proxies: number of months during which the household experienced food shortages in the last 12 months, and acres owned per capita. We implemented this regression for willingness to pay in the lean season only, at a time when food is generally more scarce and to keep all data comparable (the "last 12 month" recall period would cover different months in the harvest and lean seasons), and for those who participated in both auctions. Table 7 shows these results. Coefficients on the interactions of the two quality grades with the treatment indicator suggest similar impacts of providing training on quality premiums for households experiencing more or less food scarcity.

[Insert Table 7 here]

A simple cost-effectiveness calculation

We compared the size of unobservable quality premiums to the costs of testing and labeling groundnuts as aflatoxin-free. The amount of the unobservable quality premium (from labeling), on average across the harvest and lean seasons, was MK62/kg for informed/trained consumers and MK7/kg for uninformed/untrained consumers (Table 4). Assuming one aflatoxin test can be conducted per 100 kg bag, our estimates suggest that the increased price that producers would receive is MK6,200 per bag sold to informed/trained consumers, and MK700 per bag sold to uninformed/untrained consumers in the lean season.

During the project, the average training session took about 40-60 minutes. On average, about 25 to 40 farmers were trained per session (more than 385 farmers from 16 GACs were trained). We estimated the cost of providing training about aflatoxins to be MK2,400 per household trained, based on the costs we incurred in the project. This cost could be reduced by using cheaper deliver mechanisms (e. g. radio), by including information on more than one topic per session, and/or considering that the benefits of the provided information lasted more than one season. In our study, information about aflatoxins was not repeated to participants in the lean season, about six months after the harvest season auction, yet we found large impacts of information from the training on the unobservable quality premium in the lean season.

The other component of calculating cost-effectiveness for testing groundnut for aflatoxins before sale is the cost of testing aflatoxins themselves. Given the benefits and costs reported above, testing crops for aflatoxins would provide a positive return if aflatoxins testing costs were limited to about MK3,800 per 100 bag (about US$5). To test the groundnut we purchased and used in this study, we paid MK16,000 (about US$21) per test in a laboratory in Malawi's capital city. Reducing aflatoxin in groundnuts that are sold in rural markets potentially has broader health benefits to society that are greater than the private benefits captured in the price premium. Quantifying these benefits could be a topic of future research.

We also calculated the cost-effectiveness of the average observable quality premium created by sorting, which includes time or labor costs and the quantity lost due to the removal of broken or damaged nuts. Assuming a 10 percent quantity loss from sorting, the 10 kg lost per 100 kg bag would be valued at MK4,300 (average local market price over harvest and lean seasons was MK430/kg). Based on the labor costs incurred in the project, we estimated the cost of sorting a 100 kg bag to be MK1,500. This implies an estimated total sorting cost of MK5,800. Given our estimates of observable quality premiums for uninformed/untrained consumers (MK82/kg) and informed/trained consumers (MK116/kg) (reported in Table 4), sorting provided positive average returns of MK2,400 (US$3.20) per 100 kg bag when sold to uninformed/untrained consumers and returns of MK5,800 (US$7.75) per 100 kg bag when sold to informed/trained consumers. Given these meaningful positive returns to sorting groundnuts, understanding why farmers and traders sometimes do not sort their groundnuts could be a topic for future research.

Discussion and Conclusion

This paper contributes to the literature on seasonality, information, product quality and market development in sub-Saharan Africa. We conducted an RCT with an experimental BDM auction in Malawi to evaluate how food safety training and labeling influence rural consumers' demand for observable and unobservable grain quality attributes (sorting, and aflatoxins contamination), at harvest when grain quantity and quality is high and prices are low, and during the lean season when quality is low and prices are high.

Overall, consumers in our study were willing to pay for observable quality in groundnut, a finding consistent with Kadjo et al. (2016)'s evidence on maize during the harvest season. In addition, information through food safety training at harvest increased demand for observable quality by about MK34/kg on average, or 8 percent of the market price for the crop. Possible spillover effects of food safety information about unobservable contaminants on demand for observable quality may be an additional benefit of such information and should be taken into consideration by future research on food safety programming.

Food safety training also created demand for unobservable quality, as it increased consumers' willingness to pay for unobservable quality by about MK55/kg on average, or 13 percent of the average market price. Conversely, uninformed/ untrained consumers exhibited no unobservable quality premium for the aflatoxin safe labelled groundnut. The result confirms that aflatoxin contamination is unobservable to rural consumers in practice (Hoffmann & Gatobu, 2014; Hoffmann, Mutiga, et al., 2021).

Food scarcity and seasonality played an important role in consumers' demand for food safety. At harvest, information from food safety training increased demand for observable quality (by 22 percent of market price) but not unobservable quality. However, during the lean season training did not increase demand for observable quality, but increased demand for unobservable quality (by 16 percent of market price).

These results suggest that informed consumers who had been trained about aflatoxins did not believe the risk of aflatoxins contamination to be high at harvest. This could be due to them not fully understanding the information provided (which described how aflatoxins can contaminate crops during cultivation), and/or them having knowledge of the conditions in which crops are grown, harvested, and stored and the associated aflatoxins levels. Given that we found positive impacts of the training on willingness to pay for quality six months after the training was conducted (harvest to lean seasons), the latter reason is likely to be key.

Taken together, the findings highlight three important messages for future research and food safety programming. First, households trade off food quantity and quality in the lean season, when overall quality and quantity are both low. In this way our study adds important new information to the existing literature that has demonstrated the benefits of credit, savings and technology interventions that increase income and consumption in the lean season (Aggarwal et al., 2018; Basu & Wong, 2015; Burke et al., 2019; Channa et al., 2021; Chegere et al., 2021; Nindi et al., 2021; Omotilewa et al., 2018). However, our results suggest that simply increasing the quantity of food sold and consumed in the lean season may not be sufficient. There is need to identify and support initiatives or policy interventions that pursue both food safety and food security objectives simultaneously. The result is consistent with the idea that consumers know that crop quality (observable and unobservable) decreases over time in storage (Kadjo et al., 2016), so that solving food quality problems requires solving storage and food security issues as well. This also suggest that the "sell low and buy high" phenomenon, by which many farmers sell their crops at harvest at a low price and purchase the same food in the lean season at a high price (Burke et al., 2019), is compounded by a quality problem: sell high quality at a low price at harvest and buy low quality at a high price in the lean season.

Second, improving the quality and safety of foods that consumers buy in rural informal markets requires both informing consumers about sources of contamination *and* labeling of safe foods. Absent information through food safety training, consumers were willing to pay a very small price premium for unobservable quality in the form of labeled groundnuts at harvest, and no premium at all in the lean season when food was scarce. This result is consistent with Hoffmann, Moser, et al. (2021), and complements it with evidence from rural markets and groundnuts. The rigorous randomized design employed in the present study could explain the difference from De Groote et al. (2016), who found that information did not influence demand for observable and unobservable quality differently.

Third, the results indicate a need for policies that (1) increase the monitoring and enforcement of quality standards in rural markets, particularly during the lean season when food is scarce and consumers have priors about its average quality, and (2) promote low-cost testing of crops for contaminants. Trained consumer's high willingness to pay for quality in the lean season suggest a possible arbitrage opportunity for farmers that can maintain crop quality from harvest to the lean season, conditional on food safety information reaching consumers and labeling of safe food (and absent general equilibrium effects). Testing and labeling grain as aflatoxin safe remain prohibitive for a market for high-quality food to emerge on its own. But policy action that initially subsidizes the cost of aflatoxin testing could complement and spur market mechanisms, for the economic and health benefits of smallholder farmers, their family, and a large number of consumers. This sort of preventative food safety investment will almost certainly be more cost-effective than the paying for the longer-term health consequences of consuming unsafe food.

Competing interests statement

The authors have no competing interests to report.

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Figure 1: Study area.

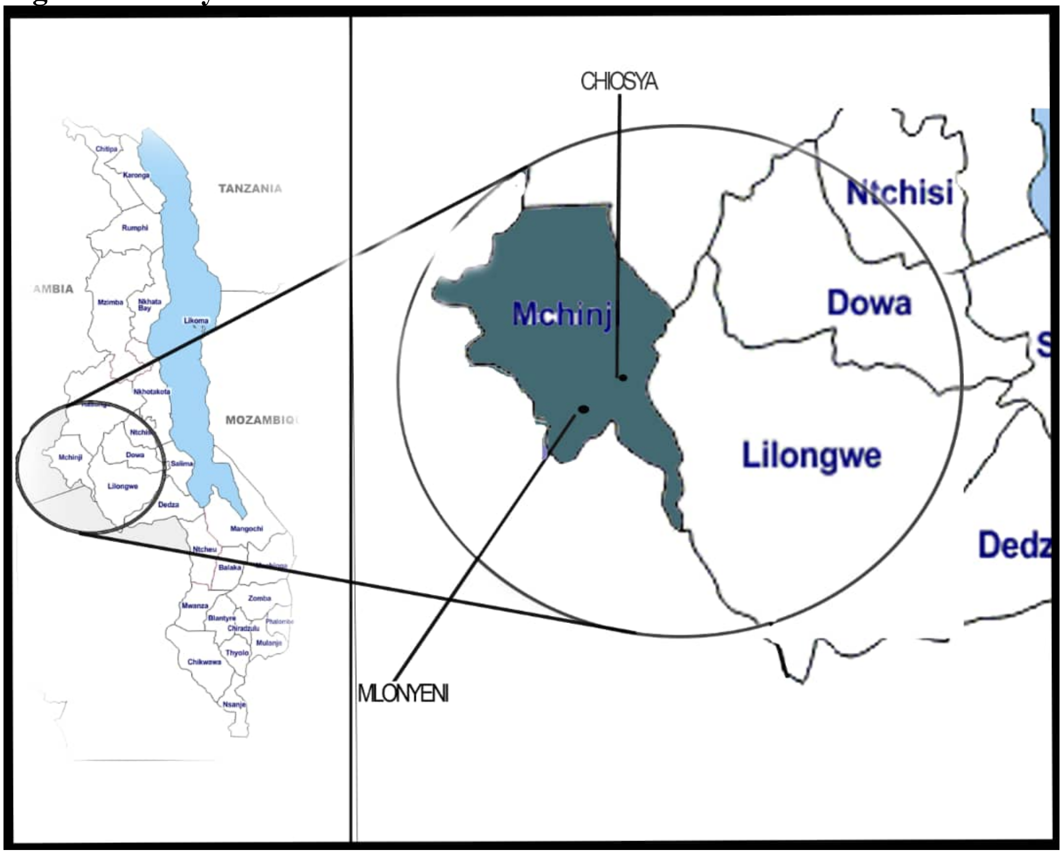
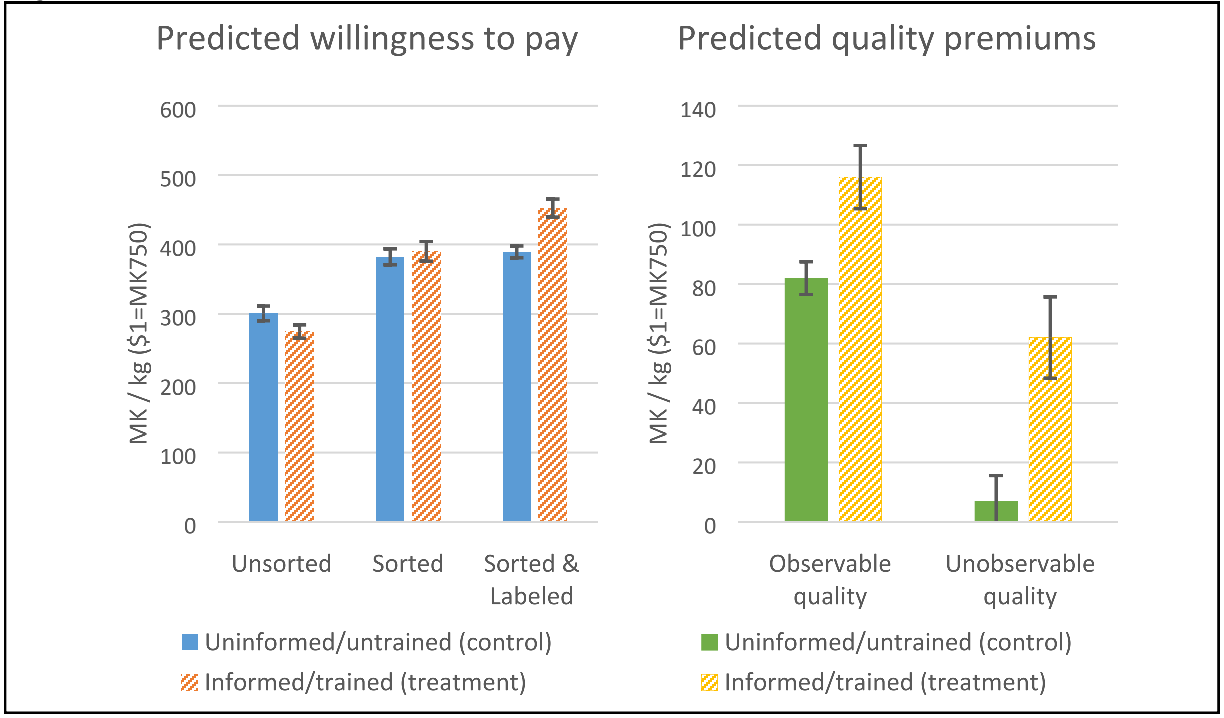
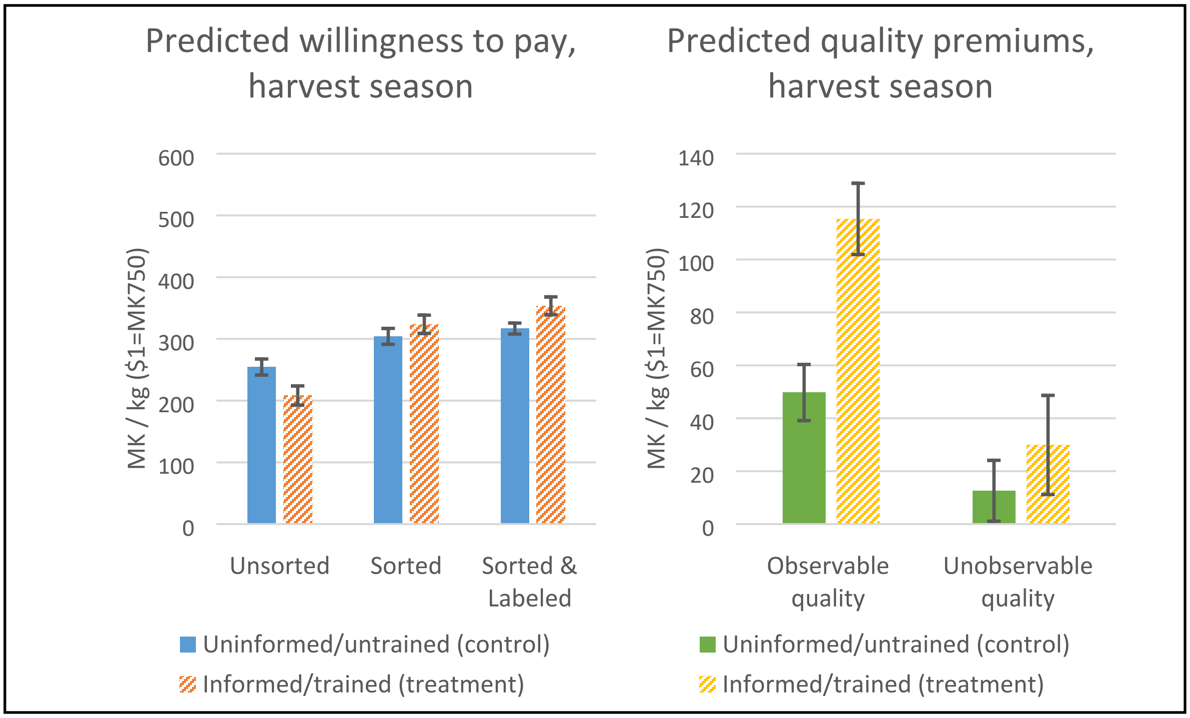


Figure 2. Impact of information/training on willingness to pay and quality premiums.



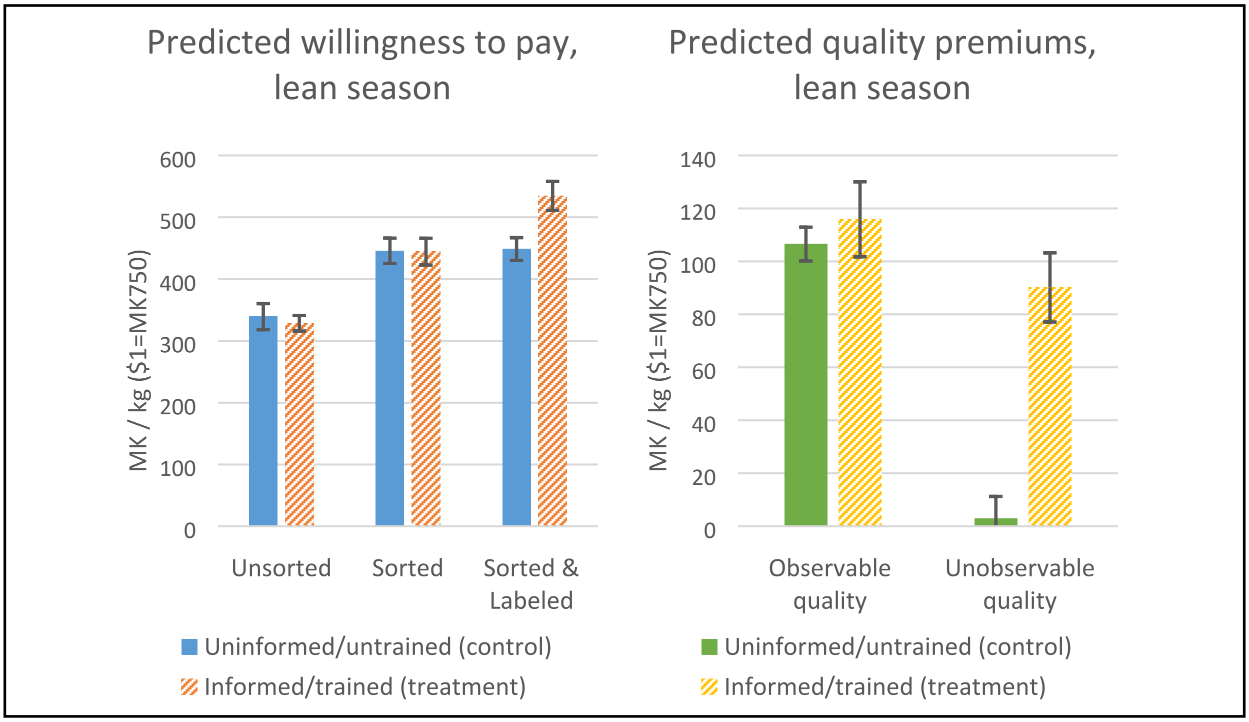
Error bars represent 95% confidence intervals. Average market price of groundnut (over harvest and lean seasons)=MK430/kg.

Figure 3. Impact of information/training on willingness to pay and quality premiums, harvest season.



Error bars represent 95% confidence intervals. Average market price of groundnut in the harvest season=MK300/kg.

Figure 4. Impact of information/training on willingness to pay and quality premiums, lean season.



Error bars represent 95% confidence intervals. Average market price of groundnut in the lean season=MK535/kg.

Table 1: Outcome descriptive statistics

	Count	Mean	Std. Dev.	Min	Max
Panel A: Overall					
WTP for unsorted groundnut (MK/kg)	1,843	289	134	0	830
WTP for sorted groundnut (MK/kg)	1,843	386	142	50	1,060
WTP for labeled groundnut (MK/kg)	1,843	418	152	70	1,210
Panel B: Harvest season					
WTP for unsorted groundnut (MK/kg)	830	233	104	0	760
WTP for sorted groundnut (MK/kg)	830	313	104	50	870
WTP for labeled groundnut (MK/kg)	830	334	103	70	740
Panel C: Lean season					
WTP for unsorted groundnut (MK/kg)	1,013	334	139	90	830
WTP for sorted groundnut (MK/kg)	1,013	445	140	60	1,060
WTP for labeled groundnut (MK/kg)	1,013	487	152	70	1,210

WTP=willingness to pay. Data are in Malawi Kwacha (MK) per kilogram; US$1=MK750.

Table 2: Household descriptive statistics

	Count	Mean	Std. Dev.	Min	Max
Baseline aflatoxins knowledge score (0-10)	1,098	3.1	3.4	0	10
=1 if baseline aflatoxins awareness score > 5	1,098	0.39	0.5		
Age of respondent (years)	1,081	39	12	17	76
Respondent's schooling (years)	1,098	5.8	3.7	0	38
=1 if respondent is male	1,098	0.46	0.5		
Household size	1,098	5.3	1.8	1	12
Landholding (acres)	1,098	3.5	1.4	0.4	10
Number of years in NASFAM	1,098	4.1	3.3	0	30
Number of school goers in household	1,068	2.4	1.6	0	9
Number of females in household	1,068	2.7	1.3	0	9
Number of adults (age>18 years) in household	1,068	2.5	1.1	0	9
Distance from home to closest market (km)	1,098	12	15	0	300
Number of extension officer visits per year	1,098	5.6	10.2	0	90
=1 if household owns radio set	1,098	0.46	0.5		
=1 had cash savings at the beginning harvest	1,068	0.25	0.4		
Storage expenditure (MK)	1,068	2,015	5,051	0	91,000
Number of months food insecure (0 to 12)	1,098	1.5	1.5	0	10
=1 if household was food insecure at least 1 month in last 12 months	1,098	0.74	0.44		
=1 if respondent too ill to farm for >2 months in past 2 years	1,068	0.19	0.4		
=1 if association is Chioshya	1,098	0.52	0.5		

US$1=MK750 (Malawi Kwacha). The baseline aflatoxins knowledge score (0 to 10) is constructed based on participants' response to 10 aflatoxins awareness questions. Min and max for binary variables are omitted for clarity.

Table 3: Observable and unobservable quality premiums, uninformed/untrained participants only.

	(1)	(2)
Dependent variable:	Willingness to pay (MK/kg)	
=1 if sorted grade (β_1)	82***	82***
	(3)	(3)
=1 if labeled grade (β_2)	89***	89***
	(5)	(5)
=1 if lean season	119***	122***
	(13)	(13)
Baseline aflatoxins knowledge score (0 to 10)		2*
		(1)
Number of years in NASFAM		1
		(1)
Constant	235***	225***
	(6)	(7)
Observations	3,030	3,030
R-squared	0.25	0.25
Number of unique bidders	600	600
Observable quality premium (β_1)	82***	82***
Unobservable quality premium ($\beta_2 - \beta_1$)	7	7
F-test: Obs. quality premium = unobs. quality premium	F=176***	F=176***

The sample is limited to uninformed/untrained participants in the control group. Coefficient names refer to equation (1). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxin knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut (over harvest and lean seasons)=MK430/kg.

Table 4: Impact of information/training on observable and unobservable quality premiums.

	(1)	(2)
Dependent variable:	Willingness to pay (MK/kg)	
=1 if sorted grade (α_1)	82***	82***
	(3)	(3)
=1 if labeled grade (α_2)	89***	89***
	(5)	(5)
=1 if household informed about aflatoxins (α_3)	-26***	-26***
	(7)	(7)
Sorted grade * Information (α_4)	34***	34***
	(6)	(6)
Labeled grade * Information (α_5)	89***	89***
	(7)	(7)
=1 if lean season (α_6)	129***	129***
	(9)	(9)
Constant	230***	227***
	(5)	(7)
Observations	5,529	5,529
R-squared	0.32	0.32
Number of unique bidders	1,098	1,098
Baseline control variables included	No	Yes
Uninformed participants (Control group):		
Observable quality premium (α_1)	82***	82***
Unobservable quality premium ($\alpha_2 - \alpha_1$)	7*	7*
Informed participants (Treatment group):		
Observable quality premium ($\alpha_1 + \alpha_4$)	116***	116***
Unobservable quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	62***	62***
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=31***	F=31***
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=51***	F=51***

Coefficient names refer to equation (2). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxin knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut (over harvest and lean seasons)=MK430/kg.

Table 5: Impact of seasonality on observable and unobservable quality premiums, uninformed/untrained participants only.

	(1)	(2)
Dependent variable:	Willingness to pay (MK/kg)	
=1 if sorted grade (α_1)	50***	50***
	(5)	(5)
=1 if labeled grade (α_2)	62***	62***
	(6)	(6)
=1 if lean season (α_6)	85***	87***
	(15)	(15)
Sorted grade * Lean season (α_4)	57***	57***
	(6)	(6)
Labeled grade * Lean season (α_5)	47***	47***
	(6)	(6)
Constant	254***	244***
	(7)	(7)
Observations	3,030	3,030
R-squared	0.31	0.31
Number of unique bidders	600	600
Baseline control variables included	No	Yes
Harvest season:		
Observable quality premium (α_1)	50***	50***
(In % of unsorted grade at harvest)	*19.7%*	*20.5%*
Unobservable quality premium ($\alpha_2 - \alpha_1$)	12*	12*
(In % of unsorted grade at harvest)	*4.7%*	*4.9%*
Lean season:		
Observable quality premium ($\alpha_1 + \alpha_4$)	107***	107***
(In % of unsorted grade in lean season)	*31.6%*	*32.3%*
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	2	2
(In % of unsorted grade in lean season)	*0.6%*	*0.6%*
F-test: Obs quality premium, harvest season = obs. quality premium, lean season	F=95***	F=95***
F-test: Unobs quality premium, harvest season = unobs. quality premium, lean season	F=2.6	F=2.6

Coefficient names refer to equation (2). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut= MK300/kg (harvest) and MK535/kg (lean season).

Table 6: Impact of information/training on observable and unobservable quality premiums, in harvest and lean seasons.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Harvest		Lean	
=1 if sorted grade (α_1)	50***	50***	107***	107***
	(5)	(5)	(3)	(3)
=1 if labeled grade (α_2)	62***	62***	109***	109***
	(6)	(6)	(5)	(5)
=1 if household informed on aflatoxins (α_3)	-46***	-45***	-11	-12
	(10)	(10)	(12)	(12)
Sorted grade * Information (α_4)	66***	66***	9	9
	(8)	(8)	(8)	(8)
Labeled grade * Information (α_5)	83***	83***	97***	97***
	(9)	(9)	(10)	(10)
Constant	254***	259***	339***	334***
	(6)	(7)	(10)	(13)
Observations	2,490	2,490	3,039	3,039
R-squared	0.18	0.18	0.19	0.19
Number of unique bidders	830	830	1,013	1,013
Baseline control variables included	No	Yes	No	Yes
Uninformed participants (Control group):				
Observable quality premium (α_1)	50***	50***	107***	107***
(In % of unsorted grade)	*19.7%*	*19.3%*	*31.6%*	*32.0%*
Unobservable quality premium ($\alpha_2 - \alpha_1$)	12**	12**	2	2
(In % of unsorted grade)	*4.7%*	*4.6%*	*0.6%*	*0.6%*
Informed participants (Treatment group):				
Observable quality premium ($\alpha_1 + \alpha_4$)	116***	116***	116***	116***
(In % of unsorted grade)	*55.8%*	*54.2%*	*35.4%*	*36.0%*
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	29***	29***	90***	90***
(In % of unsorted grade)	*13.9%*	*13.6%*	*27.4%*	*28.0%*
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=61***	F=61***	F=1.5	F=1.5
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=2.5	F=2.5	F=131***	F=131***

Coefficient names refer to equation (2). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut=MK300/kg (harvest) and MK535/kg (lean season).

Table 7: Impact of information/training on observable and unobservable quality premiums in the lean season, by proxies for food scarcity.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Lean			
Sample split:	Months food insecure in last 12 months		Acres owned/hh size	
	≤1 month	>1 month	<median	≥median
=1 if sorted grade (α_1)	112***	109***	117***	105***
	(7)	(8)	(8)	(6)
=1 if labeled grade (α_2)	113***	109***	109***	113***
	(8)	(8)	(8)	(6)
=1 if household informed on aflatoxins (α_3)	-10	8	-2	-1
	(16)	(17)	(17)	(21)
Sorted grade * Information (α_4)	6	-15	-7	1
	(13)	(12)	(11)	(10)
Labeled grade * Information (α_5)	95***	86***	94***	90***
	(13)	(14)	(11)	(15)
Constant	334***	324***	317***	337***
	(17)	(21)	(22)	(25)
Observations	1,260	975	1,137	1,098
R-squared	0.21	0.19	0.23	0.17
Number of unique bidders	420	325	379	366
Baseline control variables included	No	Yes	No	Yes
Uninformed participants (Control group):				
Observable quality premium (α_1)	112***	109***	117***	105***
(In % of unsorted grade)	*33.5%*	*33.6%*	*36.9%*	*31.2%*
Unobservable quality premium ($\alpha_2 - \alpha_1$)	2	-1	-8	9
(In % of unsorted grade)	*0.6%*	*-0.3%*	*-2.5%*	*2.7%*
Informed participants (Treatment group):				
Observable quality premium ($\alpha_1 + \alpha_4$)	118***	94***	110***	106***
(In % of unsorted grade)	*36.4%*	*28.3%*	*34.9%*	*31.5%*
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	91***	101***	93***	97***
(In % of unsorted grade)	*28.1%*	*30.4%*	*29.5%*	*28.9%*
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=0.2	F=1.6	F=0.32	F=0.02
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=53***	F=92***	F=105***	F=51***

Coefficient names refer to equation (2). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut in the lean season= MK535/kg. The median number of months food insecure in the last 12 months was 1. The median acres owned / household size was 0.625.

Online appendices

Appendix A. Aflatoxins information/training script for the Malawi food quality and safety study

We will now take you through a training session to inform you about Aflatoxins prevalence, its health effects as well as how to control or prevent contamination.

1. What are aflatoxins?

Aflatoxins are carcinogenic poisons produced by molds or fungus such as *Aspergillus flavus* and *Aspergillus parasiticus* which are usually found in improperly stored food. These toxins are invisible and tasteless such that it is hard for a consumer to detect them in their food without use of some lab equipment.

2. Which crops and foods are affected by Aflatoxins?

As pointed out earlier aflatoxins are found in improperly stored food including maize, rice, sorghum, cassava, groundnut and millet amongst other staple foods. Molds are a key indicator of aflatoxins and these can also grow in flour or spices that are not stored properly and contaminate them with aflatoxins. Feeding animals grain contaminated with molds can also affect the products we get from them such as milk as these toxins can be carried over and are difficult to neutralize. Aflatoxins cannot be neutralized by cooking or processing. Some traditional food processing procedures especially those that increase moisture content can also increase aflatoxins infestation in food.

3. Health Effects and Economic Costs

Consumption of aflatoxins in large quantities can cause aflatoxicosis. This condition involves abdominal pain, vomiting, fever, diarrhea and convulsions. There has been several publicized epidemics in other countries like Kenya and Tanzania, but it is likely that people in Malawi experience this but few reports it.

Chronic consumption of aflatoxins in small quantities which is more prevalent in Malawi is also dangerous. This is because it can suppress the immune system, cause stunting, malnutrition, especially in children. There extensive research evidence that suggest a strong correlation between chronic aflatoxins exposure and liver diseases and cancers. Besides, because maize is a staple food crop in Malawi, taking up to about 60 percent of the daily caloric intake, it is likely that Malawians may be at high risk of chronic exposure to aflatoxins. For children who are mostly feed grain-processed products like porridges and puddings (*"Phala")* as weaning foods*,* this may also be a serious health threat.

Aflatoxins contamination in grain can also pose economic threat by limiting farmers access to high value markets. For example, for export markets and local processing sectors, there are limitation in terms of aflatoxins contents for grain, as such farmers that have contaminated grain with aflatoxins level beyond the allowable levels can fail to access such markets and this can have significant effects on the economy as well as reduce incomes for farmers. There has been limited awareness about aflatoxins in Malawi with the few initiatives focused on groundnut mostly because of the need to deal with such barrier to markets. However, not much has been done to raise consumer awareness about aflatoxins prevalence in different food crops especially those sold/purchased from informal grain markets such as groundnut and maize. Our purpose is to raise awareness about aflatoxins prevalence and its health effects

4. How to Avoid Contaminations (Dealing with Practices that Proliferate aflatoxins)?

Aflatoxins contamination can be avoided in many ways in the different stages of production.

- ***During production***, farmers can use some bio pesticides like Afla-safe to control aflatoxins while the crops are still in the fields.

- ***During harvest***, farmers can avoid contamination by avoiding direct grain contact with soils i.e. not piling grain on the ground before and during harvesting.

- ***After harvest***, farmers can avoid aflatoxins contamination by ensuring that their grain is properly dried before packing as well as avoiding drying grain directly on the ground. This is because high moisture content promotes aflatoxins growth.

- ***During storage***, farmers can also further control aflatoxins by using effective storage technologies like hermetic bags (PICS bags) which have proven to be more effective at controlling molds.

Appendix B. Auction samples

Bag 4 shows the unsorted quality grade, bag 5 shows the sorted quality grade, bag 6 shows the sorted and labeled quality grade. Observable quality premium = WTP for bag 5 – WTP for bag 4. Unobservable quality premium = WTP for bag 6 – WTP for bag 5.

Appendix C. Aflatoxins-free certificate

VALID NUTRITION

Valid Nutrition, Box 202, Lilongwe, Malawi

+265 (0)1 712 488 malawi@validnutrition.org www.validnutrition.org

DATE: 15/05/2019

Sample type: Raw nut and Maize

Sample ID: Grade A & B

Test required: Total aflatoxin

Date analysis started: 15/05/2019

CERTIFICATE OF ANALYSIS

1. Mycotoxin test

SAMPLE	TEST	RESULT	UNITS	METHOD	LAB REFERENCE NUMBER
Maize (A)	Total aflatoxin	1.7	ppb	Fluorometry	CHE/19/AO/17
Maize (B)	Total aflatoxin	0.71	ppb	Fluorometry	CHE/19/AO/17
Raw nut (A)	Total aflatoxin	2.1	ppb	Fluorometry	CHE/19/AO/17
Raw nut (B)	Total aflatoxin	41	ppb	Fluorometry	CHE/19/AO/17

Declaration

The undersigned hereby certify that the data is true to the specification of the obtained results of tests

Emmanuel Mawanga

Quality Assurance and Control Supervisor

Chikondi Matiki

Quality Assurance Manager

Note: We used groundnut sample A for all auctions. The aflatoxins limits in groundnut are 4 parts per billion (ppb) in the European Union, and 15 ppb in Malawi and the United States.

Appendix D. Test of randomization balance

Dependent variable:	1 if household informed about aflatoxins (T), 0 if uninformed (C)
Baseline aflatoxins knowledge score (0 to 10)	0.018**
	(0.008)
Age of respondent (years)	0.002
	(0.002)
Respondent's schooling (years)	-0.002
	(0.005)
=1 if Respondent is male	-0.013
	(0.047)
Household size	-0.000
	(0.016)
Landholding (acres)	-0.019
	(0.039)
Number of years in NASFAM	-0.011
	(0.008)
Number of school goers in household	0.006
	(0.018)
Number of females in household	0.002
	(0.018)
Number of adults in household (age>18 years)	-0.018
	(0.015)
Distance from home to closest market (km)	-0.005
	(0.003)
No of extension officer visits per year	0.001
	(0.001)
=1 if household owns radio set	0.046
	(0.040)
=1 had cash savings at the beginning harvest	-0.043
	(0.041)
Storage expenditure (1000 MK)	-0.001
	(0.003)
Number of months food insecure (0 to 12)	-0.014
	(0.010)
=1 if member too ill to farm for >2 months in past 2 years	0.009
	(0.030)
Respondents' anchor price (1000 MK)	0.376
	(0.369)
=1 if repeated auction participant (learning effects)	0.026
	(0.083)
=1 if NASFAM association is Chioshya	0.084
	(0.202)
Observations	1,068
Chi^2-test of joint significance of all probit coefficients	$\chi^2 = 31.8$**

Coefficients are marginal effects after a probit regression. Standard errors clustered by group action center in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. 1 US$=750 Malawi Kwacha (MK). The baseline aflatoxins knowledge score (0 to 10) was constructed using participants' response to 10 aflatoxins awareness questions.

Appendix E. Test of attrition bias, household-level attrition

Dependent variable:	Dummy=1 if household attrited between harvest and lean seasons; =0 if not		
Level of analysis:	Household	Bid	Bid
Standard errors clustered by:	GAC	GAC	Household
=1 if household received information/training (T group)	0.039	0.039	0.039*
	(0.031)	(0.031)	(0.021)
Baseline aflatoxins knowledge score (0 to 10)	0.001	0.001	0.001
	(0.002)	(0.002)	(0.003)
Age of respondent (years)	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
Years of schooling for respondent (years)	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)
=1 if respondent is male	0.009	0.008	0.008
	(0.017)	(0.017)	(0.021)
Household size	0.011	0.011	0.011
	(0.008)	(0.008)	(0.010)
Landholding (acres)	-0.009	-0.009	-0.009
	(0.008)	(0.008)	(0.006)
Number of years in NASFAM	-0.015***	-0.015***	-0.015***
	(0.005)	(0.005)	(0.005)
Number of school goers in household	-0.004	-0.004	-0.004
	(0.010)	(0.010)	(0.010)
Number of females in household	-0.002	-0.001	-0.001
	(0.010)	(0.010)	(0.010)
Number of adults in household (age>18 years)	-0.009	-0.009	-0.009
	(0.011)	(0.011)	(0.011)
Distance from home to closest market (km)	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)
No of extension officer visits per year	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)
=1 if household owns radio set	-0.020	-0.020	-0.020
	(0.018)	(0.018)	(0.021)
=1 had cash savings at the beginning harvest	-0.039	-0.039	-0.039
	(0.031)	(0.031)	(0.028)
Storage expenditure (1000 MK)	-0.001	-0.002	-0.002
	(0.002)	(0.002)	(0.002)
Number of months food insecure (0 to 12)	-0.002	-0.002	-0.002
	(0.007)	(0.007)	(0.007)
=1 if member too ill to farm for >2 months in past 2 yrs.	-0.006	-0.006	-0.006
	(0.020)	(0.020)	(0.027)
Respondents' anchor price (1000 MK)	-0.109	-0.065	-0.065
	(0.238)	(0.247)	(0.295)
=1 if NASFAM association is Chioshya	0.023	0.022	0.022
	(0.036)	(0.036)	(0.022)
Willingness to pay for grain grade (1000 MK/kg)		0.013	0.013
		(0.060)	(0.052)
Observations	830	2,490	2,490
Chi^2-test of joint significance of all coefficients	$\chi^2 = 103$***	$\chi^2 = 96$***	$\chi^2 = 34$**

Coefficients are marginal effects after probit regressions. Standard errors clustered as indicated in heading in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline aflatoxins knowledge score (0 to 10) is constructed based on participants' response to 10 aflatoxins awareness questions.

Appendix F: Main model, standard errors clustered by household.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Harvest		Lean	
=1 if sorted grade (α_1)	50***	50***	107***	107***
	(6)	(6)	(5)	(5)
=1 if labeled grade (α_2)	62***	62***	109***	109***
	(6)	(6)	(5)	(5)
=1 if household informed about aflatoxins (α_3)	-46***	-45***	-11	-12
	(7)	(7)	(9)	(9)
Sorted grade * Information (α_4)	66***	66***	9	9
	(9)	(9)	(8)	(8)
Labeled grade * Information (α_5)	83***	83***	97***	97***
	(9)	(9)	(8)	(8)
Constant	254***	259***	339***	334***
	(5)	(6)	(6)	(8)
Observations	2,490	2,490	3,039	3,039
R-squared	0.18	0.18	0.19	0.19
Number of unique bidders	830	830	1,013	1,013
Baseline control variables included	No	Yes	No	Yes
Uninformed participants (Control group):				
Observable quality premium (α_1)	50***	50***	107***	107***
(In % of unsorted grade)	*19.7%*	*19.3%*	*31.6%*	*32.0%*
Unobservable quality premium ($\alpha_2 - \alpha_1$)	12**	12**	2	2
(In % of unsorted grade)	*4.7%*	*4.6%*	*0.6%*	*0.6%*
Informed participants (Treatment group):				
Observable quality premium ($\alpha_1 + \alpha_4$)	116***	116***	116***	116***
(In % of unsorted grade)	*55.8%*	*54.2%*	*35.4%*	*36.0%*
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	29***	29***	90***	90***
(In % of unsorted grade)	*13.9%*	*13.6%*	*27.4%*	*28.0%*
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=49***	F=49***	F=1.3	F=1.3
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=3.8*	F=3.8*	F=159***	F=159***

Coefficient names refer to equation (2). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut= MK300/kg (harvest) and MK535/kg (lean season).

Appendix G: Test of attrition bias, individual-level attrition

Dependent variable:	Dummy=1 if participant attrited between harvest and lean seasons; =0 if not		
Level of analysis:	Household	Bid	Bid
Standard errors clustered by:	GAC	GAC	Household
=1 if household received information (T group)	0.049	0.050	0.050
	(0.050)	(0.050)	(0.031)
Baseline aflatoxins knowledge score (0 to 10)	-0.006*	-0.006*	-0.006
	(0.003)	(0.003)	(0.005)
Age of respondent (years)	-0.002*	-0.002*	-0.002*
	(0.001)	(0.001)	(0.001)
Years of schooling for respondent (years)	-0.026***	-0.026***	-0.026***
	(0.007)	(0.007)	(0.005)
=1 if respondent is male	-0.052**	-0.052**	-0.052
	(0.025)	(0.025)	(0.033)
Household size	-0.002	-0.002	-0.002
	(0.015)	(0.015)	(0.015)
Landholding (acres)	-0.035**	-0.035**	-0.035***
	(0.014)	(0.014)	(0.010)
Number of years in NASFAM	-0.015***	-0.015***	-0.015***
	(0.005)	(0.005)	(0.005)
Number of school goers in household	-0.004	-0.005	-0.005
	(0.018)	(0.018)	(0.015)
Number of females in household	-0.028	-0.027	-0.027*
	(0.018)	(0.018)	(0.016)
Number of adults in household (age>18 years)	-0.015	-0.015	-0.015
	(0.013)	(0.013)	(0.017)
Distance from home to closest market (km)	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
No of extension officer visits per year	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.002)
=1 if household owns radio set	-0.044	-0.044	-0.044
	(0.027)	(0.027)	(0.032)
=1 had cash savings at the beginning harvest	0.029	0.029	0.029
	(0.040)	(0.040)	(0.038)
Storage expenditure (1000 MK)	0.004	0.004	0.004
	(0.003)	(0.003)	(0.003)
Number of months food insecure (0 to 12)	0.004	0.004	0.004
	(0.010)	(0.010)	(0.010)
=1 if member too ill to farm for >2 months in past 2 yrs.	0.002	0.002	0.002
	(0.029)	(0.029)	(0.039)
Respondents' anchor price (1000 MK)	-0.396	-0.292	-0.292
	(0.432)	(0.431)	(0.444)
=1 if NASFAM association is Chioshya	-0.198***	-0.198***	-0.198***
	(0.052)	(0.051)	(0.030)
Willingness to pay for grain grade (1000 MK/kg)		-0.041	-0.041
		(0.087)	(0.081)
Observations	830	2,490	2,490
Chi^2-test of joint significance of all coefficients	$\chi^2 = 300$***	$\chi^2 = 366$***	$\chi^2 = 108$***

Coefficients are marginal effects after probit regressions. Standard errors clustered as indicated in heading in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline aflatoxins knowledge score (0 to 10) is constructed based on participants' response to 10 aflatoxins awareness questions.

Appendix H. Main model, with additional control variables for individual-level attrition.

	(1)	(2)
Dependent variable:	Willingness to pay (MK/kg)	
Season:	Harvest	Lean
=1 if sorted grade (α_1)	50***	107***
	(5)	(3)
=1 if labeled grade (α_2)	62***	109***
	(6)	(5)
=1 if household informed about aflatoxins (α_3)	-48***	-6
	(8)	(10)
Sorted grade * Information (α_4)	66***	9
	(8)	(8)
Labeled grade * Information (α_5)	83***	97***
	(9)	(10)
Constant	242***	335***
	(10)	(18)
Observations	2,490	3,039
R-squared	0.19	0.21
Number of unique bidders	830	1,013
Uninformed participants (Control group):		
Observable quality premium (α_1)	50***	50***
Unobservable quality premium ($\alpha_2 - \alpha_1$)	12**	12**
Informed participants (Treatment group):		
Observable quality premium ($\alpha_1 + \alpha_4$)	116***	116***
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	29***	29***
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=61***	F=1.5
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=2.5	F=131***

Coefficient names refer to Equation 2. Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include baseline aflatoxins knowledge score, number years that the household has been a member of NASFAM, years of schooling, gender, landholding, years as a NASFAM member, and members of the Chioshya NASFAM association.

Appendix I. Main model, farmers included in harvest and lean seasons only.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Harvest		Lean	
=1 if sorted grade (α_1)	55***	55***	111***	111***
	(6)	(6)	(5)	(5)
=1 if labeled grade (α_2)	67***	67***	116***	116***
	(7)	(7)	(7)	(7)
=1 if household informed about aflatoxins (α_3)	-42***	-42***	1	-1
	(13)	(13)	(16)	(17)
Sorted grade * Information (α_4)	60***	60***	-6	-6
	(12)	(12)	(9)	(9)
Labeled grade * Information (α_5)	79***	79***	85***	85***
	(11)	(11)	(11)	(11)
Constant	253***	253***	336***	329***
	(8)	(7)	(13)	(19)
Observations	1,731	1,731	1,731	1,731
R-squared	0.19	0.19	0.19	0.20
Number of unique bidders	577	577	577	577
Baseline control variables included	No	Yes	No	Yes
Uninformed participants (Control group):				
Observable quality premium (α_1)	50***	50***	111***	111***
Unobservable quality premium ($\alpha_2 - \alpha_1$)	17**	17**	5	5
Informed participants (Treatment group):				
Observable quality premium ($\alpha_1 + \alpha_4$)	115***	115***	105***	105***
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	31***	31***	96***	96***
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=27***	F=27***	F=0.4	F=0.4
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=1.9	F=1.9	F=61***	F=61***

Coefficient names refer to Equation 2. Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM.

Appendix J. Main model, with triple interaction.

	(1)	(2)
Dependent variable:	Willingness to pay (MK/kg)	
=1 if sorted grade	50***	50***
	(5)	(5)
=1 if labeled grade	62***	62***
	(6)	(6)
=1 if household informed about aflatoxins	-46***	-46***
	(10)	(10)
Sorted grade * Information	66***	66***
	(8)	(8)
Labeled grade * Information	83***	83***
	(9)	(9)
=1 if lean season	85***	86***
	(14)	(14)
Sorted grade * Lean	57***	57***
	(6)	(6)
Labeled grade * Lean	47***	47***
	(6)	(6)
Information * Lean	35*	36**
	(17)	(17)
Sorted grade * Information * Lean	-56***	-56***
	(10)	(10)
Labeled grade * Information * Lean	14	14
	(12)	(12)
Constant	254***	252***
	(6)	(7)
Observations	5,529	5,529
R-squared	0.19	0.19
Number of unique bidders	1,098	1,098
Baseline control variables included	No	Yes

Standard errors clustered by GAC in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM.

Appendix K. Main model, with triple interaction, farmers in both the harvest and lean season auctions.

	(1)	(2)
Dependent variable:	Willingness to pay (MK/kg)	
=1 if sorted grade	53***	53***
	(6)	(6)
=1 if labeled grade	64***	64***
	(6)	(6)
=1 if household informed about aflatoxins	-45***	-45***
	(12)	(11)
Sorted grade * Information	63***	63***
	(9)	(9)
Labeled grade * Information	83***	83***
	(9)	(9)
=1 if lean season	85***	85***
	(16)	(16)
Sorted grade * Lean	58***	58***
	(8)	(8)
Labeled grade * Lean	47***	47***
	(8)	(8)
Information * Lean	43*	43*
	(21)	(21)
Sorted grade * Information * Lean	-65***	-65***
	(10)	(10)
Labeled grade * Information * Lean	9	9
	(12)	(12)
Constant	252***	249***
	(7)	(8)
Observations	4,470	4,470
R-squared	0.34	0.34
Number of unique bidders	745	745
Baseline control variables included	No	Yes

Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM.

Appendix L. Main model, with binary variable for learning effects at the household level.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Harvest		Lean	
=1 if sorted grade (α_1)	50***	50***	107***	107***
	(5)	(5)	(3)	(3)
=1 if labeled grade (α_2)	62***	62***	109***	109***
	(6)	(6)	(5)	(5)
=1 if household informed about aflatoxins (α_3)	-46***	-45***	-11	-12
	(10)	(10)	(12)	(12)
Sorted grade * Information (α_4)	66***	66***	9	9
	(8)	(8)	(8)	(8)
Labeled grade * Information (α_5)	83***	83***	97***	97***
	(9)	(9)	(10)	(10)
=1 if repeated auction participant household (learning effects)	-2	-3	7	-5
	(8)	(8)	(9)	(11)
Constant	257***	261***	334***	336***
	(9)	(10)	(12)	(13)
Observations	2,490	2,490	3,039	3,039
R-squared	0.18	0.18	0.19	0.19
Number of unique bidders	830	830	1,013	1,013
Baseline control variables included	No	Yes	No	Yes
Uninformed participants (Control group):				
Observable quality premium (α_1)	50***	50***	111***	111***
Unobservable quality premium ($\alpha_2 - \alpha_1$)	17**	17**	5	5
Informed participants (Treatment group):				
Observable quality premium ($\alpha_1 + \alpha_4$)	115***	115***	105***	105***
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	31***	31***	96***	96***
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=61***	F=61***	F=1.5	F=1.5
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=2.5	F=2.5	F=131***	F=131***

Coefficient names refer to Equation 2. Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM.

Appendix M. Main model, with binary variable for learning effects at the individual level.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Harvest		Lean	
=1 if sorted grade (α_1)	50***	50***	107***	107***
	(5)	(5)	(3)	(3)
=1 if labeled grade (α_2)	62***	62***	109***	109***
	(6)	(6)	(5)	(5)
=1 if household informed about aflatoxins (α_3)	-46***	-45***	-11	-12
	(10)	(10)	(12)	(12)
Sorted grade * Information (α_4)	66***	66***	9	9
	(8)	(8)	(8)	(8)
Labeled grade * Information (α_5)	83***	83***	97***	97***
	(9)	(9)	(10)	(10)
=1 if repeated auction participant individual (learning effects)	6	7	3	-5
	(6)	(6)	(9)	(9)
Constant	250***	254***	338***	336***
	(7)	(8)	(11)	(13)
Observations	2,490	2,490	3,039	3,039
R-squared	0.18	0.18	0.19	0.19
Number of unique bidders	830	830	1,013	1,013
Baseline control variables included	No	Yes	No	Yes
Uninformed participants (Control group):				
Observable quality premium (α_1)	50***	50***	111***	111***
Unobservable quality premium ($\alpha_2 - \alpha_1$)	17**	17**	5	5
Informed participants (Treatment group):				
Observable quality premium ($\alpha_1 + \alpha_4$)	115***	115***	105***	105***
Unobs. quality premium ($\alpha_2 + \alpha_5 - \alpha_1 - \alpha_4$)	31***	31***	96***	96***
F-test: Obs quality premium, uninformed = obs. quality premium, informed	F=61***	F=61***	F=1.5	F=1.5
F-test: Unobs quality premium, uninformed = unobs. quality premium, informed	F=2.5	F=2.5	F=131***	F=131***

Coefficient names refer to Equation 2. Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxins knowledge score and the number years that the household has been a member of NASFAM.

Appendix N. Questions used in aflatoxins knowledge test.

1. Have you ever heard of aflatoxins?
2. Are molds key indicators of aflatoxins?
3. Which crops [maize] are most affected by aflatoxins?
4. Which crops [groundnuts] are most affected by aflatoxins?
5. Does moisture promote aflatoxin proliferation?
6. Does drying on the ground promote aflatoxin contamination?
7. Can hermetic storage control aflatoxin contamination?
8. Does piling (mkukwe) promote aflatoxin proliferation?
9. Can consumption of aflatoxins contaminated food cause diarrhea?
10. Can chronic consumption of aflatoxin-contaminated food cause liver cancer?

Appendix O: Observable and unobservable quality premiums, uninformed/untrained participants only.

	(1)	(2)	(3)	(4)
Dependent variable:	Willingness to pay (MK/kg)			
Season:	Harvest		Lean	
=1 if sorted grade (β_1)	50***	50***	107***	107***
	(5)	(5)	(3)	(3)
=1 if labeled grade (β_2)	62***	62***	109***	109***
	(6)	(6)	(5)	(5)
Baseline aflatoxins knowledge score (0 to 10)		-1		4**
		(1)		(2)
Number of years in NASFAM		-0		1
		(1)		(2)
Constant	254***	260***	339***	322***
	(6)	(8)	(11)	(14)
Observations	1,335	1,335	1,695	1,695
R-squared	0.067	0.068	0.116	0.125
Number of unique bidders	445	445	565	565
Observable quality premium (β_1)	50***	50***	107***	107***
Unobservable quality premium ($\beta_2 - \beta_1$)	12*	12*	2	2
F-test: Obs. quality premium = unobs. quality premium	F=14**	F=14**	F=317***	F=316***

The sample is limited to uninformed/untrained participants in the control group. Coefficient names refer to equation (1). Standard errors clustered by GAC in parentheses. *** p<0.01, ** p<0.05, * p<0.1. *** p<0.01, ** p<0.05, * p<0.1. US$1=MK750 (Malawi Kwacha). Group action centers (GAC) are community-level clusters; the assignment to treatment and control was done at the GAC level. Baseline control variables include the baseline aflatoxin knowledge score and the number years that the household has been a member of NASFAM. Average market price of groundnut=MK300/kg (harvest) and MK535/kg (lean season).