How do traders and consumers in sub-Saharan Africa value maize moisture content? Evidence from an experimental auction in Senegal

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Abstract

In SSA, if maize moisture content cannot be detected, traders and consumers have no incentive to dry maize to ≤ 13.0 percent moisture, resulting in fungal growth and aflatoxin contamination. Using an experimental auction in SSA, we elicit trader and consumer WTP for maize labeled with varying moisture contents. Participants revealed a preference for drier maize when they knew the moisture content, but could not distinguish between unlabeled maize dried to ≤ 13.0 percent moisture and 14-15.9 percent moisture.

Buyers signal their market preferences through the prices they are willing to pay for products and specific product attributes. However, buyers cannot send price signals for attributes that are not readily observable. If attributes are also not observable to sellers, then neither party can use prices to signal their preferences. Developed countries typically use laboratory tests and labeling laws to improve buyer information about unobservable food product attributes. In the U.S., maize moisture content is measured with relatively high cost moisture meters and traded by volume and weight. For example, traded maize is standardized to 15.5 percent moisture, which weighs 56 lbs. per bushel.

However, such structures are often weak or non-existent in developing countries. Thus for an attribute like maize moisture content that may not be observable by buyers or sellers, there may not be an incentive to dry maize sufficiently. This is especially true when maize is only traded by weight, and not volume, as wetter maize will weigh more and thus benefit the seller.

Maize is the largest cereal crop produced in Sub-Saharan Africa (SSA) (APHLIS, 2015). To assure no fungal growth during storage, maize should be dried within 3 days of harvest to ≤ 13.0 percent moisture content. Storing damp maize increases the risk of spoilage by fungi. Several *Aspergillus* fungal species (primarily *A. flavus*) produce aflatoxins, which are potent liver toxins associated with increased cancer risk as well as negative effects on nutrition and immune systems in humans and animals.

As moisture meters are not readily available in most rural markets in SSA, this study's objectives are to determine the reliability of local methods of maize moisture detection and the value of maize moisture. This is especially important in markets where maize is traded on weight, and not volume as in our study area of Senegal. We test two main null hypotheses that to our knowledge remain largely unanswered:

H_1: When moisture content is <u>unknown</u> to buyers, there is no difference in the prices offered for maize of varying moisture contents.

H_2: When moisture content is <u>known</u> to buyers, there is no difference in the prices offered for maize of varying moisture contents.

To test the hypotheses, we conducted the experimental auctions in the Kolda region of Southern Senegal from October 26 to November 12, 2015, randomly surveying 240 professionals involved in the maize trade (traders, millers, and small processors) and 182 consumers (422 participants).

Some extension documents note that "experienced" farmers can detect maize moisture content by biting or pinching the kernel to estimate its hardness, or by the different sound shaken maize kernels make when they are drier (Hodges and Stathers, 2012). However, we could find no study to validate this assumption.

There is little documentation about the preferences of Senegalese maize professionals and consumers for drier maize. Previous studies of moisture content preferences in Kenya found that Kenyan traders were willing to pay 2.7 percent more for maize at moisture levels below 13.5 percent than for maize of unknown moisture (Ordoñez and Hoffmann, 2013). However, Kenya has a developed standards body and formal sector that pays a premium for lower moisture maize. Senegal's standards body, like many SSA countries, does not have the capacity to regulate the safety of maize and test moisture content on a large scale (Ahmet Sow, personal communication, October 9, 2015).

Previous experimental auctions in Africa have documented results for observable attributes, or when an information asymmetry exists (i.e. at least one party as information about the unobservable attribute). Buyers were willing to pay a 20 percent price premium for own-grown maize over maize of similar visible quality; an 11 percent premium for maize from a neighbor; a 12 percent premium for maize they had tasted; and a 7 percent premium for maize certified as aflatoxin free (Hoffmann and Gatobu, 2014). Choice experiments documented a 3 percent price discount for a 10 percent increase in insect damage; the discount was more pronounced in the harvest season (Kadjo, et al., 2016). Additionally, the length of time a trader intended to store maize affected the discount he offered for insect damaged grain (Jones, et al., 2012). Thus, when maize is labeled with its moisture content level, we expect to see different prices offered and to be able to distinguish maize moisture preferences.

Background

Under the assumption that neither buyers nor sellers can perfectly detect moisture content, we would expect formal contracts to reward other, observable maize attributes. Formal contracts constitute only 1 percent of all Senegalese maize production, they pay a fixed price for maize meeting desired levels of a variety of different attributes (Aïssatou Diagne Dème, personal communication, October 6, 2015; Ka and Seck, 2013-2015). The observable attributes in formal contracts are a maximum level of insect remains, ash (farmers sometimes use fires underneath a raised platform to dry maize), sand/ dirt (farmers often solar dry maize in open-air conditions, which increases dirt blowing on the kernels), and a minimum level of whole grains. The unobservable attributes are minimum levels of protein and moisture (12 percent), and maximum fat levels. However, testing of unobservable attributes is rarely done, as samples must be sent to an outside lab at a high cost. The negative correlation between ash/ sand content and moisture content could result in an unintentional dis-incentivizing of reduced moisture content. Thus, it is important to formally test if maize professionals and consumers can detect maize moisture content, without the use of a moisture meter.

Methods and Data

Published Senegalese maize prices are only disaggregated by month, region, and sale point (farmgate v. retail), and not by quality attributes such as moisture content. Some maize buyers in the Senegalese formal sector specify moisture content levels in their contracts, but the attribute is lumped with whole grain percentages, insect remains, and sand content when setting the maize price. Asking a hypothetical price for varying moisture contents could overstate the attribute's value by a factor of three (List and Gallet, 2001). Thus, the preferred method to elicit values in Senegal is to sell maize of varying moisture content, and control for any other perceived variations in the maize. In Senegal, we used two different incentive-compatible auction mechanisms to elicit participants' true values for six types of maize with varying moisture contents.

Data

We conducted the experimental auctions in Kolda region from October 26 to November 12, 2015, and surveyed 182 consumers, 166 resellers, 56 small processors, and 18 maize millers (422 participants). Although the latter are service providers that typically do not buy maize and only sell amounts paid in-kind for their services, millers' values for drier maize may reflect buyer values, hence why they were included in the study.

The auctions were held in the seven largest urban and rural markets in the Kolda region (Kolda, Diaobé, Vélingara, Manda Douane, Saré Yoba, Medina Yoro Foulah, and Bayoungou). In the three locations that have a daily market (Kolda, Diaobé, Vélingara), we rented a small shop for four days each in which to conduct the auctions and minimize passer-by interest. In the remaining four weekly markets, on the corresponding market day enumerators targeted every reseller, miller, and small processor they could locate. In all seven markets, enumerators approached every third consumer for auction participation.

Auction structure

In the auction, we used two practice rounds (with bonbons and pens) before eliciting maize values to help participants understand three key concepts:

1) Strategic behavior was not to their advantage, i.e. they should bid their true value for each type of maize;
2) They would bid for each of the 6 types of maize, but only one type would be randomly selected for sale to avoid diminishing marginal returns on subsequent maize bids; and
3) That their bid would be compared to all other bids that day (for re-sellers and millers) or to a randomly determined amount (consumers and small processors) to determine if they had the 'high' offer for the randomly selected maize-type.

For re-sellers and millers that were accustomed to working with 50 kg sacks, their bids were made throughout the day for an entire 50 kg sack and placed in envelopes. At the end of each day, the 50 kg sack that was randomly selected for sale that day was sold to the highest bidder at the second-highest bid price (Vickrey, 1961). We chose this rolling sealed-bid approach, as opposed to organizing a group auction in one location, for re-sellers and millers who had limited time to leave their shops and to inspect/ bid on the maize[1]. For consumers and small processors, we used the Becker-Degroote-Marchand (BDM) mechanism in which participants bid on a 1 kg of maize. If their bid was greater than or equal to an amount selected at random by the participant from an opaque bag, they purchased the maize at the randomly selected amount (Becker, et al., 1964). The thirteen possible amounts in the opaque bag were uniformly distributed between 25 CFA and 325 CFA, and increased in increments of 25 CFA. In October 2015, the prevailing maize price in Diaobé and Vélingara was 175 CFA, thus we chose 6 amounts above and below 175 CFA for the random distribution. [2]

After the practice rounds, the enumerator walked the participant to an unlabeled maize bag, asked their bid, or willingness to pay (WTP) for either 1 or 50 kg of maize from the bag, and then asked the participant a series of questions about that maize-type. The unlabeled maize-types were presented to each participant in a randomly varied order (as were the subsequent labeled maize-types). After being shown all three unlabeled maize-types, enumerators showed participants a moisture meter and explained its purpose. The enumerator then walked the participant over to a randomly selected labeled maize-type, showed them the corresponding label, and explained the label's meaning. As 35 percent of participants had no formal schooling and only 5 percent knew what a moisture meter was, explaining the label's content and its meaning (low, medium, or high moisture) was necessary in the local context. Enumerators then asked the participant's WTP for that labeled maize-type and the same series of questions.

[1] We credit Romina Ordoñez and Vivian Hoffman for providing us the idea for this approach.
[2] In October 2015, the exchange rate was 580 CFA/ 1 USD. The average maize price was ~$0.30/ kg and the increments were ~$0.04 each.

All of the maize used in the auction (~1 MT) was procured from a large farmer near Pakour, Vélingara in the Kolda region. We conducted the auction during harvest season when maize of varied moisture content was available, and sun-dried most of the maize ourselves, to achieve precisely the targeted moisture variation. The moisture content of each maize-type was re-verified with a moisture meter every morning, to ensure it had not acquired additional moisture overnight in the humid climate. We chose three moisture levels, ≤ 13.0 percent, 14.0-15.9 percent, and 17.0-19.0 percent, leaving a 1 percent gap to create distinct moisture content levels.

Empirical model

Our data consists of WTP bids for six different maize-types from each of our 422 auction participants. This creates a panel data set of 2,532 observations differentiated by the maize-type on which the participant bid. The regression model is

$$WTP_{ij} = \beta_0 + \beta_1 X_{i\,15\%} + \beta_2 X_{i\,18\%} + L_{ij}\alpha + \gamma_1 L_{ij} * X_{i\,15\%} + \gamma_2 L_{ij} * X_{i\,18\%} + Z_{ij}\delta + c_i + \varepsilon_{ij} \quad (1)$$

where

- The dependent variable is the WTP of participant *i* for maize-type *j*, in CFA/ kg.
- $X_{i\,15\%}$ is a binary variable for maize at 14.0-15.9 percent moisture
- $X_{i\,18\%}$ is a binary variable for maize at 17.0-19.0 percent moisture
- L_{ij} is a binary variable where all labeled maize = 1 and unlabeled maize = 0

- $L_{ij}X_{i\,moisture}$ are interaction binary variables for labeled maize at the specified moisture percentage
- Z_{ij} contains the other regressors specific to each participant and maize-type. Z_{ij} includes the order in which the maize was presented to the participant (1 - 6). We also included five binary regressors indicating whether the participant considered each maize-type safe for 1) human and 2) animal consumption; and storage for 3) one, 4) three, and 5) six months. Z_{ij} also includes the number of days prior to the auction the maize was procured.
- c_i absorbs maize-type invariant observed and unobserved participant-specific characteristics.
- ε_{ij} is the unobserved error term

Low moisture content ($\leq$ 13.0 percent) is set as the control in the model. As such, $\hat{\beta}_0$ indicates the WTP for unlabeled maize at $\leq$ 13.0 percent moisture content, while $\hat{\alpha}$ indicates the WTP for labeled maize at $\leq$ 13.0 percent moisture content. In our auction setting, L_{ij} and X_{ij} are varied experimentally, theoretically removing the possibility of biased coefficient estimates caused by correlation between the respective coefficients and c_i. However, we include Z_{ij} in our main specification to control for factors that could have influenced a participant's perceptions about moisture content and other characteristics of the maize-types on which they were bidding. We estimate equation (1) using both participant fixed effects (FE), which removes c_i from the estimating equation, and participant random effects (RE), which includes c_i in the estimating equation and allows for estimation of maize-type invariant factors.

Hypotheses Tests

Using the unlabeled lowest moisture content (≤ 13.0 percent) as the control, if a Wald statistic indicates the restriction $\hat{\beta}_0 = \hat{\beta}_1 = \hat{\beta}_2$ in equation (1) holds, we will fail to reject H_1: When moisture content is unknown by buyers, there is no difference in the prices offered for maize of varying moisture content. If a Wald statistic indicates the restriction $\hat{\gamma}_1 = \hat{\gamma}_2 = \alpha$ holds, we will fail to reject H_2: When moisture content is known to buyers, there is no difference in the prices offered for maize of varying moisture contents.

Results

Across all maize-types, unconditional mean WTP decreased in moisture content. At ≤ 13.0 percent moisture, unconditional WTP for maize labeled with its moisture content was higher vs. unlabeled. However, at 14-15.9 percent and 17-19 percent moisture, unconditional WTP was lower for labeled vs. unlabeled maize (Table 1).

Table 1. Unconditional mean WTP by moisture content and participant type (CFA/ kg)

Participant type	≤ 13.0%		14.0-15.9%		17.0-19.0%	
	Unlabel	Label	Unlabel	Label	Unlabel	Label
Professionals	125	136	119	111	112	95
Consumers	169	178	155	149	151	133
All Participants	144	154	135	128	129	111

In equation (1), unlabeled maize at ≤ 13.0 percent is the control type. Thus, interpretation of all other coefficients is in relation to this maize-type (Table 2).

Table 2. Regression results

		FE	RE
Experimentally varied parameters			
Unlabeled ≤ 13.0% (β_0)		121.78*** (6.59)	182.13*** (10.74)
Unlabeled 14.0-15.9% (β_1)		-0.38 (2)	-0.92 (3.14)
Unlabeled 17.0-19.0% (β_2)		-6.9*** (2.38)	-8.66*** (3.52)
Labeled ≤ 13% (α)		-14.91*** (2.78)	-14.78*** (4.27)
Labeled 14.0-15.9% (γ_1)		-23.82*** (2.94)	-23.7*** (4.31)
Labeled 17.0-19.0% (γ_2)		8.47*** (2.97)	9.17** (4.4)
Additional maize-type variant regressors			
Maize-type is safe to store for:	1 month	0.13 (1.62)	0.07 (2.24)
	3 months	4.22*** (1.71)	2.38 (2.22)
	6 months	4.6** (2.1)	5.02* (3.11)
Maize-type is not safe:	Needs cleaning	5.3** (2.68)	2.85 (3.47)
	Needs drying	-10.45*** (2.34)	-7.27*** (3.04)
	Needs sorting	-5.21 (4.71)	-9.17* (5.77)
	Needs protectants	2.21 (4.84)	-1 (6.1)
If win auction, will:	Consume this maize-type	6.16*** (2.53)	3.39 (2.91)
	Sell this maize-type	10.55*** (2.97)	6.81** (3.36)
	Plant this maize-type	15.6*** (3.86)	7.99** (4.51)
	Feed animals this maize-type	-0.48 (4.74)	-0.13 (5.64)
Presentation order		-0.07 (0.68)	-0.33 (1.03)
Previously purchased similar quality		1.44 (2.04)	3.91* (2.79)
Number of days since maize-type was procured		-0.77*** (0.23)	-1.07*** (0.32)
Maize-type invariant regressors			
Maize professional			-5.91*** (0.5)
Years experience selling maize			0.03** (0.01)
Years family experience cultivating maize			-0.09 (0.17)
If I win auction, I will store maize for __ weeks			-0.07 (0.13)
Age			-0.34*** (0.09)
Gender			-11.47*** (4.29)
Spoke to previous auction participant			-9.2** (4.54)
Know what moisture meter is			-7.54** (4.16)
R-squared		0.73	0.36

(robust standard errors)
*p<0.10,** p < 0.05, *** p < 0.01

The two model specifications, participant fixed effects (FE) and random effects (RE), found the same signs and significance for the experimentally varied parameters. However, because some coefficients differed by large amounts, we ran a robust-Hausman test which failed to reject the null of the RE specification (χ^2 = -4.85). Thus, we report both the maize-type variant and invariant regressors.

Experimentally varied parameters

All of the experimentally varied parameters, save unlabeled maize at 14-15.9 percent moisture, differ significantly from the control. When maize at ≤ 13.0 percent moisture was labeled, participants were willing to pay more for it. Additionally, participants did not make significantly different offers for unlabeled maize at 14-15.9 percent moisture and maize at ≤ 13.0 percent moisture. Graphically, we can see that WTP declined in moisture content (Figure 1).

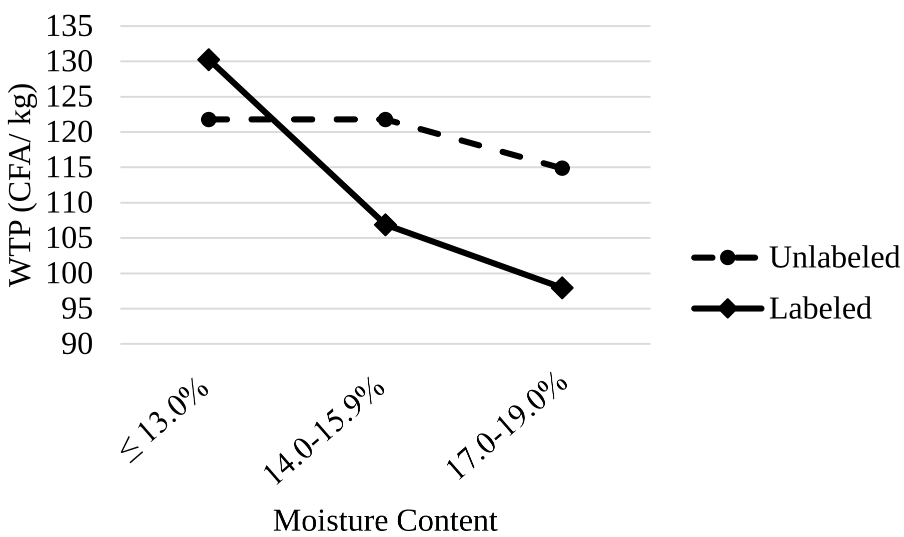

Figure 1. WTP (CFA/ kg) by moisture content and labeling (FE estimates)

Hypothesis Tests

We reject both our null hypotheses, with Wald statistic = 248.68 and 31.56 for H_1 and H_2, respectively ($p<0.01$). Participants' WTP did vary for both unlabeled and labeled maize. Although we reject H_1, since participants did not have significantly different WTP for unlabeled maize at 14-15.9 percent moisture, participants may not have been able distinguish between maize moisture content at the two lowest levels.

Other maize-type variant regressors

If the participant thought the maize was suitable for 6 months of storage, it significantly increased their WTP in both the FE and RE specifications. Also, if the participant did not feel the maize was safe because it needed drying, this significantly decreased their WTP. If participants intended to sell or plant the maize from the auction, both factors significantly increased their WTP. Finally, neither the order in which the maize-types were presented nor if the participant had purchased a similar quality maize previously significant affected their WTP.

The number of days since the maize had been procured was highly significant and negative, not surprising to those managing the auction. The maize began to discolor over the auction period, with many of the highest moisture content maize kernels blackening. The latter required an additional purchase from the same supplier, hence we controlled for the number of days since the maize had been procured.

Maize-type invariant regressors

Participants that worked with maize professionally had significantly lower WTP than consumers, as implied by the unconditional mean WTP in Table 1. Trading experience was a significant predictor of maize WTP. Although the coefficient was small, professionals offered 0.03 CFA/ kg more for the unlabeled maize at ≤ 13.0 percent for each additional year of experience. However, this was not true for consumers whose families' had experience cultivating maize.

Women's WTP was significantly higher than men's. The older the participant, the lower their WTP, but by less than 1 CFA/ kg per additional year of age. Although not shown in Table 2, five of the seven individual markets were significant predictors of maize WTP, as were four of the seven enumerators.

Conclusions

Importantly, the findings for labeled moisture content maize extend beyond the price premium expected for dryer maize due to density differences. Unlike maize in the U.S. (and Kenya), Senegalese maize is sold by weight, not volume. Since water is less dense than the materials that give a maize kernel its nutritional value (flour, bran, oil, etc.), lower moisture content maize weighs more when it occupies the same volume container as higher moisture content maize.

For example, in our study the highest moisture content was 19 percent. At this moisture, 50 kg of maize would occupy a 0.072 m^3 container. When maize at 13.0 percent moisture content occupies the same container, it would weigh 56 kg. The buyer would get about 12 percent more maize. Thus, to describe the higher WTP offered for the maize at ≤ 13.0 percent as a "premium," it needs to be at least 12 percent greater than the WTP for the maize in the 17-19 percent range. The mean WTP for labeled maize in Table 1 was 111 CFA/ kg for maize at 17-19 percent moisture content. As participants WTP was 33 CFA/ kg more for maize with ≤ 13.0 percent moisture, or WTP was 29 percent higher, our auction results show a WTP premium does exist for dryer maize.

Future efforts

Despite the challenges of drying maize, maize traders, processors, millers and consumers place a price premium on lower moisture content maize. However, they are not able to distinguish between maize dried to 14-15.9 percent moisture and maize dried to ≤ 13.0 percent moisture content without the benefit of a moisture meter. With high temperatures and relative humidity, drying to ≤13.0 percent within 3 days of harvest is critical to reduce fungal growth and the probability of aflatoxin contamination. Future work in this area should focus on finding a cost-effective means to enable those involved in the maize trade, and those producing their own maize, to detect maize moisture content.

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