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THE BUSINESS CASE FOR LOW-COST MOISTURE METERS IN SUB-SAHARAN AFRICA

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Introduction

Drying grain to low levels of moisture content (MC) before storing is essential for preserving safe, nutritious food throughout the year. Unfortunately, proper post-harvest drying of grain is difficult for smallholder farmers and small-scale traders in rural areas of sub-Saharan Africa (SSA) because of three significant challenges. First, MC is difficult to accurately measure in places where commercial grade moisture meters (costing more than $200 per device) are unaffordable and unavailable. Without this technology, most people rely on traditional methods to assess grain moisture. These include, biting, use of sounds and touching kernels, which can indicate general levels of MC, but are not accurate. For example, if maize is just above the 13.5% MC threshold where mold and fungi can grow, the dryness levels can be mistaken. Second, drying grain is relatively costly. For example, the cost of drying can represent 5-10% of the value of maize, creating disincentive to dry fully to safe levels if it is intended for sale (De Groote et al. 2021). Third, there is further disincentive to dry grains in many parts of SSA, because they are often sold by either volume or weight. Dry grains weigh less and occupy a lower volume compared to wet grains; therefore, sellers earn more money when grain is sold wet (Prieto, Ricker-Gilbert, Bauchet, & Sall, 2021). The lack of accurate and affordable moisture detection devices in rural areas creates a limited incentive to dry crops to levels needed for safe storage and consumption. If grain is not dried below 13.5% MC before storage, then dangerous contaminants such as aflatoxins can propagate.[1]

FIGURE 1: Hygrometer and DryCard™ Notes: The figure above shows the DryCard™ at the top and the hygrometer at the bottom. The DryCard™ and the hygrometer on the left are in a bag of dry maize and on the right, wet maize.

In response to these challenges, two low-cost moisture detection devices have recently been developed with funding by USAID.[2] First, the hygrometer is a simple device that measures relative humidity and temperature in the air. When placed in a small hermetic bag with a handful of grain, the grain and air moisture provide an accurate measurement of maize MC (Tubbs, Woloshuk, and Ileleji 2017).[3] Second, the DryCard™ is a laminated strip of cobalt chloride paper, which changes color depending on the humidity levels in the atmosphere. The color change has been calibrated for specific humidity

[1] Aflatoxins are known to cause liver cancer and have been linked to malabsorption of nutrients and stunting in children (Hoffmann, Jones and Leroy 2018).

[2] Specifically, we do not consider variations of commercial grade moisture meters including the GrainMate because these meters cost around $70, and likely serve a different segment of the market (e.g.: large scale aggregators and millers) than do the hygrometers and DryCard™. More information about the GrainMate can be found here https://www.k-state.edu/phl/resources/GrainMate%20Fact%20Sheet%20Sept2018-fix.pdf

[3] The hygrometer was adapted for moisture detection as part of the Food Processing and Post-Harvest Handling Innovation Lab at Purdue University.

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levels. Like the hygrometer, the DryCard™ is placed in a sealed container with grain to be tested for MC. A blue-colored strip indicates that the maize is sufficiently dry and ready for storage, and a pink-colored strip indicates that the maize is too wet for storage (Thompson et al., 2017).[4] Both devices take about 10-20 minutes to produce an accurate reading, which is a disadvantage over commercial grade moisture meters that give instant readings (see figure 1). However, when comparing price with commercial meters, the low-cost meters create a possible opportunity in the market for small-scale producers and traders to adopt the technologies and use them. The hygrometer retails for about $2.50-$3.00 in Kenya and gives a more accurate numerical reading of temperature and relative humidity that can be converted to MC. The DryCard™ has a lower price point, retailing for about $1.00 in Kenya, but gives a less accurate reading of MC.[5]

The objective of this brief is to summarize what is known about the market potential for commercializing and scaling these low-cost moisture detection devices for smallholder farmers and small-scale traders in SSA. Most of this research draws from peer reviewed publications and market assessments with evidence from Kenya. Though low-cost moisture detection devices can potentially solve an important problem (ie: assessing moisture content in grains to preserve safe food), the challenges mentioned above inhibit their uptake. That being said, the level of awareness about the dangers of aflatoxin is growing in many countries. In addition, some millers and government buyers now test for MC before procuring grain, and many people recognize that traditional methods for testing MC are inaccurate and unreliable for safe grain storage and sales. This suggests that the market for low-cost moisture detection devices have a large potential to impact food safety in SSA, and these markets could be developed if the right conditions are in place. The rest of the brief describes what is known about potential commercialization strategies for low-cost moisture detection devices.

I. Selling devices directly to smallholder farmers and small-scale traders

The most direct method for commercializing low-cost moisture detection devices is to sell them directly to smallholder farmers and small-scale traders. To test the size of this market, in 2017 Channa et al. (2021) conducted an auction among smallholder farmers and small-scale traders in Kakamega County, western Kenya. Participants were asked to bid real money on both the hygrometer and DryCard™ to purchase one of the devices. They found that most people were only partially confident that their traditional methods for detecting moisture (touching, biting, etc) were accurate (on average 2.3 out of 5-point scale). However, the mean bid for the hygrometer was $1.25, suggesting some willingness to pay, but only about 10% of participants were willing to pay at or above the market price of $2.50. The mean willingness to pay for the DryCard™ was about $0.90, suggesting that the average level of demand was closer to the market price of $1.00 for the DryCard™, as compared to the hygrometer. In addition, Fuller and Ricker-Gilbert (2021) conducted a similar auction among maize traders in western Kenya and found that there was no difference in demand when the hygrometer was offered to participants at $2.00, $2.50, or $3.00 price points. However, only 15% of the sample were willing to purchase the device regardless of which of these prices were offered, indicating that a relatively small segment of the rural population saw value in the MC device in the current context and the current point. This suggests that there is need for an information campaign to demonstrate the benefits of MC devices over traditional moisture detection methods.

II. *Selling devices directly to actors further up the value chain.*

Small-scale traders may have a better understanding of grain moisture than do smallholder farmers, as it relates to the cost of drying and prices received for grain of different MC levels. Regardless, they have no incentive to value MC if actors on either end of the supply chain do not value it. However, some large-scale traders, millers, and government buyers are willing to pay a premium for grain with lower MC, as they sell to a segment of consumers who value food quality and safety. As these large-scale actors deal in large volumes and may already have a commercial grade moisture meter, they likely would not be interested in the low-cost devices that take 10+ minutes to reach equilibrium. But these large-scale actors could potentially sell or offer free hygrometers and DryCards™ to their contract farmers and traders they buy grains from, enabling their suppliers to test and more accurately dry the grain in preparation for sale.

[4] The DryCard™ was developed as part of the Horticulture Innovation Lab at UC Davis.

[5] Smallholders farmers and traders in the informal markets of Kenya have been trained and sensitized on these two promising technologies through the Feed the Future Innovation Lab for Food Processing and Post-harvest Handling extension activities.

III. *Third-party service providers testing moisture content*
Another option for commercializing low-cost moisture detection devices is to have a third party, not associated with the grain transaction, charge a small fee for testing grain moisture before a sale. This person could operate in the village, to capture the point of sale at the farm gate or at rural markets for transactions between other market actors, and be available to test grain before a trade takes place. The benefit of the third-party moisture detection service would be that a buyer and a seller would not have to incur the full cost of purchasing a moisture detection device or worry about manipulation of the MC reading by their potential trading partner. Fuller and Ricker-Gilbert (2021) tested the potential for a third-party moisture detection service among traders in Western Kenya and found that the traders were willing to pay an average of $0.28 for a MC reading of their maize that was tested by a hygrometer, and $0.39 for a MC reading from a commercial grade moisture meter that cost about $300 in Kenya. This suggests that traders valued the accuracy of the commercial meter over the hygrometer. However, the hygrometer's much lower cost ($2.50) compared to the commercial moisture meter ($300) makes the former a more viable business option for a limited-resource individual to act as a third-party tester.

IV. *Bundling devices with other post-harvest products.*
The low-cost moisture detection devices are potentially complementary products to other innovative post-harvest technologies like hermetic (airtight) grain storage bags. When closed properly, the hermetic bags solve the problem of insects damaging grain in storage by choking off their air supply. Unlike moisture detection, the problem of insect damage is very visible and salient to most farmers. As a result, hermetic bags have been commercialized extensively in SSA over the past ten years. However, the main challenge in their use is that the grain must be well dried (below 13.5% MC), and the hermetic bag must be properly sealed for it to effectively preserve safe grain during storage. As such, there is a potential for input suppliers to bundle and market the low-cost moisture detection devices to consumers as an additional product that is sold along with the hermetic bag. This may enhance adoption of both hermetic bags and moisture detection devices, as quality enhancing complimentary products.

Conclusions and Recommendations

Low-cost moisture detection devices including the hygrometer and DryCard™ can potentially help solve an important problem of assessing grain moisture before sales and storage occur, with relatively good accuracy at a much lower price than commercial-grade moisture meters. While these devices solve the problem of moisture assessment, most smallholder farmers and small-scale traders in rural markets of SSA are not incentivized to appreciate and pay for such assessments at the present time. Recent research indicates that relatively few farmers and traders in Kenya were willing to purchase low-cost moisture devices at or around their market price. This suggests that creative strategies on the part of governments, donors, and the private sector are needed to promote moisture assessment tools that can improve food quality and safety among rural populations in SSA. We conclude with the following recommendations for encouraging commercialization and scaling of these low-cost moisture detection devices.

1. *Public support:* There is need for governments and donors to invests in accelerated training programs about the importance of grain moisture assessment tools and the advantages of low-cost moisture detection devices over traditional methods. Moisture assessment should be incorporated in earnest as part of all post-harvest extension training modules that includes drying, handling, and storage.
2. *Larger-scale actors:* Larger-scale traders, millers, and government buyers who offer a price premium for grain that is dried to safe levels could support the sale of hygrometers and DryCards™ to smaller-scale farmers and traders who sell grain to them. This would enable smaller-scale actors who supply larger-scale buyers with the opportunity to test their grain for dryness before delivering it, hence reducing losses and time incurred in drying and transporting.
3. *Third-party testing:* A third party operator, potentially under-employed rural youth and women groups could potentially purchase low-cost moisture detection devices and set-up moisture testing services at rural markets, grain aggregation centers or travel to rural villages to offer the measurement services. This would provide new

employment opportunities, and would benefit small-scale farmers and traders as they could get an accurate, unbiased moisture reading before a transaction, without incurring the cost of purchasing the device themselves.

4. *Bundling:* Encouraging input suppliers to bundle low-cost moisture detection devices with the sale of hermetic bags to encourage the adoption of both products. Since the effectiveness of hermetic bags depends on the grains being dried enough for storage, it should be in the interest of input suppliers to train and offer hygrometers and DryCards™ to their customers along with the hermetic bags. This will help ensure that customers have good experiences with the hermetic bags and return to buy more in the future.

Evidence for this brief draws on the following peer-reviewed journal articles:

Channa, H., J. Ricker-Gilbert, H. De Groote, J. Bauchet. 2021. "Willingness to pay for a new farm technology given risk preferences: Evidence from an experimental auction in Kenya." (Forthcoming) *Agricultural Economics*.

Fuller, A., and J. Ricker-Gilbert. 2021. "Is there a market for third-party quality verification in rural grain markets? Evidence from an experimental auction for moisture testing in Kenya" (Forthcoming) *Journal of African Economies.*

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