ABSTRACT

Title of Dissertation: DEMAND FOR SAFER FOOD IN DEVELOPING COUNTRIES

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According to the WHO, in less developed countries approximately 2.2 million people—most of whom are children—die annually of food and waterborne diseases. In these economies, information on the safety attributes of food is usually not available and enforcement of food safety regulations is often weak, particularly within markets for locally consumed food. Still, food safety in the developing world has long been considered a secondary concern relative to food availability. The goal of this dissertation is to contribute to a deeper understanding of some of the constraints that surround demand for safer food along food supply chains in developing countries. Consumers' demand for safe food can be thought of as an investment in preventive health, which has been shown to be extremely low in developing countries. Hence, this dissertation contributes to the economics literature that explores the impact of health-related information on preventive health behaviors in poor countries.

This dissertation focuses on the role of food safety information in affecting people's purchase behavior in a developing country setting. Because food safety is mostly a credence attribute that cannot be ascertained—or is too costly to ascertain—even after consumption, the provision of information has an important role to play in the reduction of information asymmetries inside the food chains. Among the several actors that are involved in food value chains, this dissertation focuses on small-scale informal intermediaries and consumers. The effect of information on these actors' demand for safer food is assessed through the estimation of willingness to pay for food labeled as having safer characteristics, and through the analysis of the effect of different types of health-related information on the decision of whether or not to purchase food advertised as safer to eat. To achieve this, two field experiments using revealed preference methods were conducted in Kenya, where maize, the staple food, is frequently contaminated with aflatoxin, a naturally-occurring fungal toxin that is harmful to human health.

A brief introductory chapter is followed by a comparison of the advancement of food safety policy and research in developed countries with the corresponding evolution in developing countries (Chapter 2).

The framed field experiment described in Chapter 3 tests whether maize traders in informal markets are willing to pay more for higher quality and safer maize. 369 traders from different markets across Kenya participated in a second-price sealed-bid auction in which information on moisture content and aflatoxin contamination of maize auctioned was varied experimentally using labels. The results show that information on moisture content significantly affects traders' willingness to pay and suggest the observability of moisture content is limited. Also, the effect of information does not appear to be driven by the possibility of selling drier maize to the formal sector, nor by the intention to keep the dryer maize for own family consumption. Further, the impact of providing traders with information on aflatoxin contamination is over twice as large as the effect of moisture content information. These results show that there is potential for strengthening the price-quality relationship within this context by increasing the availability of information on maize quality and safety.

Chapter 4 presents the results of a field experiment conducted among customers of small retail shops in Nairobi and smaller urban centers in eastern Kenya. Packages of maize flour were tested for aflatoxin, labeled as safe to eat when they complied with the aflatoxin regulation, and offered for sale at a 20% premium above the price of untested maize. Information messages about the health consequences of aflatoxin exposure and about local contamination prevalence were randomly varied across customers as they entered the shops. The results show that the impact of health messaging on purchase of tested maize varies significantly depending both on the specific content of the message, and on the characteristics and prior beliefs of consumers. Information on the local prevalence of aflatoxin contamination, which exceeded the vast majority of customers' contamination priors, had the strongest impact on demand. This study demonstrates that combining information on the prevalence of a risk with its health consequences is an effective approach for encouraging preventive health behavior.

DEMAND FOR SAFER FOOD IN DEVELOPING COUNTRIES

by

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Dissertation submitted to the Faculty of the Graduate School of the
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Dedication

To my Family.

To my mother and brother, two fierce fighters, who have taught me to never EVER give up.

To my father, who has encouraged me to believe in myself since I was a little child, assuring me that I would achieve my goals, no matter how small or ambitious.

To my sister, who repeatedly told me with all her love that I would succeed, and to my beautiful nephews, who fill my life with happiness.

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Chapter 1: Introduction

In many developing areas of the world, consuming food can be much riskier than in developed economies. The limited access to technology and infrastructure that would make food production, storage, transportation and commercialization safer for human consumption makes food more prone to contamination. Also, a large portion of food consumed in the developing world comes from households' own farm production, which is hard to regulate and monitor. Moreover, the lack of regulation governing the production and processing of food for local consumption and the weak enforcement of existing regulations contribute to worsening local food safety. Even when there is political will to enforce existing regulations, the lack of affordable technology and knowledge to enforce cost-effective regulations, makes it difficult for poor countries to accomplish the endeavor. As a result, unsafe food has a significant role in the large burden of disease borne by developing countries, and is therefore an important public health issue. For instance, in less developed countries, approximately 2.2 million people—most of whom are children—die annually of food and waterborne diseases, which are difficult to disentangle (WHO, 2002; Hoffmann, 2010).

Therefore, improving food safety in developing countries is an urgent matter that would benefit from understanding what is the demand for safer food at every link in the food supply chains. Although research contributions related to food safety in developed economies can provide some guidance, strengthening food safety in poor countries requires a different approach from that followed in advanced economies. Food demand in developing countries is much more affected by budget constraints than in developed countries, so consumers' responses when faced with safer food alternatives in richer countries might differ a great deal from those of more income-constrained consumers in poor settings. Further, food safety comprises several unobservable or imperfectly observable characteristics, which can make it hard for consumers and other agents in the value chain to recognize the quality of the food they consume. This problem is exacerbated in developing countries due to the small-scale and informal nature of food production and markets, as well as their often weak regulatory environments. The absence of certifications and information labels in these settings leads to uninformed consumption choices that can have negative health consequences. To make matters worse, poor countries' consumers are frequently unaware of these food-related health risks. This highlights the key role played by access to food safety and quality information.

This dissertation focuses on the role of food safety information in affecting people's purchase behavior in a developing country setting. In particular, I analyze the impact on demand of information related to: i) food characteristics directly linked to food safety (such as the absence of harmful toxins or moisture content); ii) risk prevalence; and iii) health consequences of eating unsafe food. Because food safety is mostly a credence attribute that cannot be ascertained—or is too costly to ascertain—even after consumption, the provision of information has an important role to play in the reduction of information asymmetries inside the food chains. Demand for safe food can be thought of as an investment in preventive health, which has been shown to be extremely low in developing countries. Further, there is evidence that households in poor countries are often unaware of the health risks they face and the cost of not knowing them, as well as of the benefits of investing in preventive health behavior (Dupas, 2011b). Hence, this study contributes to the literature that explores the impact of health-related information on preventive health behaviors in poor country settings.

Several lines of research have centered on the topic of valuation of food safety and other food quality characteristics. However, the majority of these studies have been conducted in developed countries. In contrast, the valuation of food safety related to products locally consumed in developing countries has been much less studied. One of the reasons for this is that food safety regulation has gone through more than a century of consistent progress in the industrialized world, whereas the development of food safety policy in developing countries is a relatively more recent phenomenon. Another reason is that food safety in the developing world has been considered for a long time a secondary concern relative to food availability. I begin this dissertation by comparing the advancement of food safety policy and research in developed countries with the corresponding evolution in developing countries in order to explore the reasons why food safety regulation in developing economies is lagging behind. In trying to answer this question, particular effort was put into trying to detect the different types of drivers that have led to policy changes in this field in the developed and developing areas of the world. This serves as a contextual framework and motivation for the main topic studied in this dissertation: the demand for safer food in developing countries.

Among the several actors that are involved in the food value chains, this dissertation focuses on small informal intermediaries and consumers. The effect of information on demand is assessed through the estimation of willingness to pay for food labeled as having safer characteristics, and through the analysis of the effect of different types of health-risk information on the decision whether or not to buy food advertised as safer to eat. To achieve this, two field experiments using revealed preference methods were conducted in Kenya, a Sub-Saharan country with high levels of staple food contamination with naturally-occurring toxins.

Naturally occurring fungal toxins—mycotoxins—are one of the most serious food safety problems affecting staple crops, especially maize and groundnuts, in developing countries.[1] Also, due to their influence on trade and livestock production, mycotoxins can have large economic impacts (Grace et al., 2015). Maize contamination with aflatoxins, the most potent type of mycotoxins and the most carcinogenic organic substances on earth, is the food safety issue chosen for this dissertation. Aflatoxins cause around 90,000 cases of liver cancer annually and are strongly associated with immunosuppression and stunting in children (Grace et al., 2015). Aflatoxins are highly prevalent in many developing areas of the world, especially tropical and subtropical regions, and local populations are generally unaware of their health consequences. Hence, aflatoxin contamination of staple food is a serious threat for public health and development in poor countries with high aflatoxin contamination prevalence.

Among the more than 40 crops that are prone to aflatoxin contamination, maize was selected for this dissertation because it is the most important staple food in many Sub-Saharan countries and it is one of the worst afflicted crops. Maize is the main staple

[1] The other broad categories of food contaminants are: i) pathogenic bacteria, viruses and parasites; and ii) chemical contaminants, such as agrochemical residues and environmental contaminants. The former have been thoroughly studied in developing country settings, and the latter, although not as much studied in these settings, are mostly considered an occupational hazard rather than a food safety one (Hoffmann, 2009). Hence, my dissertation focuses on the less studied food safety issues among the most relevant to developing countries.

food in Kenya, where this research is conducted. [2] In Kenya, high levels of aflatoxin contamination have been found in farmers' maize stocks, in maize sold in informal markets and in processed packages of maize flour for sale at local shops. The fact that 75% of Kenyan maize production is grown by smallholder farmers makes tracing contaminated maize and testing for aflatoxins extremely hard and costly, which aggravates the contamination problem in the country (Guantai and Seward, 2010).

I conducted two field experiments that use aflatoxin-contaminated maize in Kenya as the setting to test the effect of certain types of food-related information on food demand. The first experiment (which I will call the "traders experiment") estimates informal traders' willingness to pay for maize grains with certain attributes—moisture content and aflatoxin contamination—through the use of auctions. This experiment aims to understand if incentives can be created inside the maize value chain in order to encourage the production of safer food and the safer handling of food before reaching consumers. The second experiment (which I will call the "consumers experiment") intends to assess if there exists consumer demand for food labeled as safe to eat, and how it can be influenced through the provision of information relevant for consumers' decision-making process. Both experiments use revealed preference methods to assess the impact of information on behavior. While the first experiment focuses on one link of the value chain, the second experiment focuses on another.

Harrison and List (2004) developed a classification of field experiments that includes: artefactual field experiments; framed field experiments; and natural field

[2] Maize constitutes 36% of the daily caloric intake of the average Kenyan, and its annual per capita consumption rate is around 98 kilograms (Abele et al., 2006; FAOSTAT). Maize is also the main crop in Kenyan agriculture, being grown by 98% of smallholder farmers (Kirimi et al., 2011).

experiments. The traders experiment fits clearly in the category of framed field experiment, as it consisted of having real maize traders in real open air markets reflecting on their valuation of maize bags of different qualities and submitting bids for them. Using Harrison and List (2004)'s terminology, I worked with a nonstandard subject pool, an imposed set of rules, and field context in the commodity (maize bags), task (purchasing maize bags) and information the subjects could use (maize characteristics, maize prices). Because traders knew that they were part of a research experiment, it cannot be considered a natural field experiment. The consumers experiment shares several characteristics with a natural field experiment because I worked with real shop customers in field context in the commodity, task and information they could use, and on top of this, there was no set of rules to follow and customers did not know that their purchase decisions would later be observed (though they were asked for consent to participate in a research study when first approached). Because people tend to exhibit stronger moralistic and pro-social behavior when they know they are being scrutinized (Levitt and List, 2005), natural field experiments can help obtain truer valuations.

Some of the questions that will be answered in the two chapters where I describe the experiments are the following: Are informal traders willing to pay more for maize labeled as having higher quality and being safer to eat? How valuable is this information for traders, given that they use their own simpler methods to assess maize quality? Are maize consumers willing to pay a premium for aflatoxin-safe labeled maize? Can certain types of information, such as contamination prevalence or health consequences of aflatoxin exposure, have a larger effect on consumers' food purchase decisions? Does the effect of information depend on consumers' characteristics?

If consumers are willing to pay a premium for safer food, the incentives of all other agents in the value chain could be aligned with the ultimate objective of producing safer food. Processors and traders in these settings might then be willing to also pay a premium for safer inputs and products. Further, when farmers are aware of the existence of a price premium for safer agricultural production, they can also have the incentive to use safer practices and inputs in their production. What is more, assessing willingness to pay is particularly important in settings—such as the one studied here—where institutional and government budget constraints are large and hence cost-sharing with the private sector can be a solution (Guiteras et al, 2015).

Given the complexities of food production and sale in poor country settings, there is still a lack of agreement among the development community on how food safety problems should be tackled. What is undeniable is that improving food safety in these contexts requires understanding the constraints and incentives faced by all actors in the food value chain: farmers, processors, traders, regulatory agents, and consumers. The two experiments described in this dissertation aim to shed light on the incentives of some of the participants in a staple food value chain: traders and consumers. These findings can contribute to the design of public policies and international donor's interventions that can help reduce the burden of disease caused by the consumption of unsafe food.

Several projects and studies are currently being conducted to try to improve the safety of food produced and consumed in poor countries. For example, the development of biological-control products to reduce staple food contamination with aflatoxins is currently underway in several Sub-Saharan African countries (IITA, 2013; IITA, 2014). The study of demand for safer food in these settings can be a useful input for the implementation at larger scales of new solutions found to the problem of widespread consumption of unsafe food.

The dissertation is organized as follows. In chapter 2, I discuss the evolution of food safety regulation in industrialized countries since the end of the 19th century, compared to developing countries, focusing on the different drivers that have led to stringent regulations in this field in these two groups of economies. I also describe the literature that centers on the valuation of safer food in developed countries—highlighting the main topics studied and findings—and compare it to the thin existent literature that studies the demand for safer food in developing countries. Chapter 3 presents the traders experiment and Chapter 4 describes the consumers experiment. Chapter 5 concludes.

Chapter 2: Evolution of food safety policy and research around the world in the last century

2.1 A comparison of the drivers of food safety reforms between developed and developing economies

The story of the evolution of modern food safety policy can be seen as a succession of responses to food and drug related scandals that had huge economic costs and a significant toll on human health and life. For over a century, food safety concerns arising from these scandals have resulted in strong regulatory responses from governments in the industrialized world. However, the advancement of these policies in the developing world has been much more recent, slower and incomplete than in developed countries[3], and it is mostly responding to a different type of drivers.

The beginning of the 20th century brought about big changes in food safety policy in the industrialized world. Encouraged by vast technological progress during the last decades of the 19th century, food production and processing had experienced a huge transformation as they moved away from a local to an industrial scale, and food marketing and distribution got to know much wider limits. Several food safety scandals (e.g. the "embalmed meat scandal" in the US) created pressure to have new food safety policies and regulations in order to manage the new risks to human health.4 These crises,

[3] The use of the terms "developing country", "developed country", "middle income country", "high income country" and "low income country" is based on the United Nations' country classifications, detailed in the World Economic Situation and Prospects 2015.

[4] US troops combating in Cuba during the Spanish-American War in 1898 were fed rotten canned beef that was later blamed for killing "more troops than Spanish bullets did" (Johnson, 1982). Even though, according to Keuchel (1974), it was not proved that it was the canned beef what killed the troops, the "embalmed beef scandal", as was popularly called, helped raise public awareness of the dangers of eating unsafe meat.

together with emerging medical and bacteriological research that contributed to spread awareness of food-related health risks, indicated that policies and institutions that had been managing food risks until then were not able to protect consumers anymore in more integrated economies (Hoffmann and Harder, 2010; Spiekermann, 2010).

In the US, the enactment in 1906 of the Pure Food and Drugs Act, the first major food safety law, was the response to a strong public demand for change in this field. There were two main factors that led to an increase in public pressure and a decrease in the sales of certain food products that became unsafe in consumers' eyes. First, a public official and chemist (Harvey W. Wiley) led a grass root movement concerned about the use of unsafe chemicals in food processing—the Pure Foods Movement—and, as chief of the Bureau of Chemistry (now the Food and Drug Administration, FDA), conducted studies that brought national awareness to the problem. Second, a journalist's work showed the health violations and unsanitary practices that were taking place in the meatpacking industry.[5] Three decades later, a new food safety scandal that involved a drug containing a poisonous ingredient that killed over 100 people accelerated the enactment in 1938 of the improved Food, Drug, and Cosmetic Act, which remains the basis of current FDA regulation.

Some European countries went through similar processes in the modernization of their food safety policies. In some cases, due to the increase in international food trade that was taking place at the end of the 19th century, food safety became a source of disputes between developed countries. For instance, before 1880 Germany saw over 500 people die of trichinosis, which led the government to take food safety measures in the

[5] In 1906, the journalist Upton Sinclair published the novel The Jungle, which was turned into a movie in 1914.

pork industry, such as the implementation of an extensive control system that included 25,000 pork inspectors (Spiekermann, 2010). The lack of application of similar measures in the US led Germany to ban imports of US pork between 1880 and 1891. This decade of intense trade disputes between the two countries—later called the German–American Pork War—put pressure on the US government to implement pork safety measures in the local industry.

The end of the 20th century and the beginning of the current century saw a new series of food safety crises in the developed world (e.g. the "mad cow disease" scandal in Europe) that brought food safety policy under the spotlight and started a new wave of policy reforms that is still under way (Hoffmann and Harder, 2010; Hoffmann, 2010; Unnevehr and Hoffmann, 2015).[6] The globalization of the world economy, characterized by an unprecedented volume of global fresh-food trade, as well as technological advances that radically modified agricultural production, processing and transportation, have produced huge changes in food supply chains worldwide. These changes have also created a very clear challenge for public health (as well as for agricultural health): globalized food trade can spread foodborne diseases across different countries and continents much more rapidly. Further, progress made in food hazard detection and epidemiology has increased knowledge and awareness of food-related problems. The World Trade Organization (WTO)'s Sanitary and Phytosanitary (SPS) Agreement, which has incorporated standards from the Codex Alimentarius Commission, has been—since

[6] The Bovine Spongiform Encephalopathy (BSE) or "mad cow disease" crisis that started in the UK in the mid 1980s caused over 200 deaths and severely affected the beef industry in the UK and the rest of the EU for more than a decade. Other examples of recent food safety scandals are: the Belgian dioxin crisis in 1999 that affected several agricultural industries due to animal feed contamination with carcinogenic dioxin and polychlorinated biphenyls (PCBs); and the several Chinese exports found to be adulterated with melamine, such as wheat gluten exported to the US in 2007, which was blamed for killing thousands of pets.

1995 when it came into effect—an international attempt to deal with some of these new challenges, setting new harmonized rules for international agricultural trade.[7] Responses at the national and regional levels include, for example, the passing in 2002 of a new EU-wide integrated food safety law (the General Food Law), and the implementation of major food safety legislative reforms by many other OECD countries since the 1990s (Hoffmann and Harder, 2010).

Both internal and external factors have led to this second generation of food safety policy reforms in the developed world. In the case of the UK, which faced intense pressure from local consumers due to the poor handling of the "mad cow disease" crisis, the drivers have been mainly internal. Other countries, such as Canada and Australia, which have traditionally been exporters of agricultural products, have strengthened their food safety regulations and monitoring mostly because of external factors, i.e., the goal to maintain access to existing export markets and gain access to new markets (Hobbs et al., 2002).

As part of the large changes to global food production and trade described above, developing countries began to experience similar pressure to improve their food safety regulation systems (Jaffee and Henson, 2004; Hoffmann and Harder, 2010; Swinnen and Vandeplas, 2011). The integration of world markets and the globalization of food supply chains that have taken place in the last three decades have created big opportunities for developing countries—in particular middle income countries—that have had the chance to export nontraditional agricultural products to high-income countries (Diaz-Bonilla and

[7] The Codex Alimentarius Commission was established in 1963 by the United Nations' Food and Agriculture Organization (FAO) and World Health Organization (WHO) as an international technical organ that would develop food safety and quality standards.

Reca, 2000; Reardon and Barrett, 2000; Pingali, 2007).[8] At a macroeconomic level, food exports to richer markets have contributed to increase developing countries' foreign exchange earnings. At a microeconomic level, export-oriented farmers and industries in developing countries have benefited from higher prices, sales and income (Jaffee and Henson, 2004; Reardon et al., 2009; Maertens et al., 2012).

However, for most developing countries it has been a challenge to profit from increased global food trade, as local institutions lacked the capacities to regulate food production, processing and distribution in order for export products to comply with importing countries' rising food safety and quality standards (Reardon et al., 1999; Reardon and Farina, 2001; Reardon et al., 2009).[9] Further, the fact that these regulations can introduce new non-tariff technical barriers to trade that could be used by developed countries in a discriminatory or protectionist manner, increased developing countries' concerns of their ability to comply with them (Jaffee and Henson, 2004). What is more, not only the public sector but also the private sector had its own limitations in terms of capacity to comply with these higher standards. Changes in the institutional framework and regulatory capacity were needed, in this case, not to manage changes in local health risks, but to be able to export food products to countries with more stringent regulations, while minimizing bans and consignment rejections. Hence, efforts to strengthen food safety policy were driven by market access requirements related to high-value export

[8] Traditional agricultural exports include commodities such as coffee, sugarcane, cacao, beef, cotton and bananas. Non-traditional agricultural exports comprise high-value fresh and processed fruits and vegetables, flowers and nuts.

[9] Examples of public and private food safety and quality requirements that are often faced by developing country exporters are: the accreditation of specific quality and private management certifications (such as HACCP, ISO, GlobalGAP, etc.); the abiding by maximum pesticide residue limits in fresh produce and by limits to other contaminants (such as mycotoxins in certain grains and nuts); and the adoption of traceability systems.

products (Unnevehr and Hoffmann, 2015). While a century ago developed countries had to deal with regulating food production and trade in newly nationally-integrated economies, developing countries have recently had to adapt their food production and food safety regulation systems—or part of them—to the requirements of a globalized economy. In the process of adapting to stringent standards and regulations, developing countries have sometimes faced trade disruptions and export bans and have incurred in high compliance costs to achieve and maintain market access (Unnevehr and Ronchi, 2014).[10]

What this process has created in many developing countries is the coexistence of double standards in the regulation of food safety. The case of India is a perfect example, as food safety is regulated by two distinct governmental agencies: the Export Inspection Council (EIC), the main export regulatory and certification body; and the recently created Food Safety and Standards Authority of India (FSSAI), in charge of governing the safety of processed food for sale in the local market.[11] In the 1990s, India began to suffer several export rejections, detentions and bans that affected a range of food products including spices, peanuts, mangoes, grapes, tea, eggs, dairy and marine products (Das, 2008). Pressure from importing countries as well as the WTO through its standards

[10] Examples of trade losses are: Thailand's revenue losses from maize exports due to aflatoxin contamination above the importing countries' accepted levels, estimated to be around $50 million per year; India's drop in peanut meal exports to the EU by more than $30 million per year after stricter mycotoxin regulations were imposed by the EU in the early 1980s (Dohlman, 2003). Some examples of export bans imposed by developed countries to developing countries due to noncompliance with food safety standards include: EU bans on fishery products from Bangladesh in 1997, from Kenya in 1997-2000 and from Malaysia in 1998; and US ban on Guatemalan raspberries in 1997-1998 (Unnevehr and Ronchi, 2014).

[11] The passing in 2006 of the Food Safety and Standards Act transformed the previously uncoordinated and ineffective Indian food safety system and created a single responsible agency (for the domestic market), the Food Safety and Standards Authority of India (FSSAI) (Epstein, 2011).

stimulated reform in the export sector's food safety regulation, which required large investments in laboratories and the creation of adequate expertise. This regulatory reform later served as a model for domestic reform—that started with the creation of the FSSAI in 2006—through the transfer of knowledge, rules and production practices (Epstein, 2011). As Epstein (2011) states in her PhD dissertation on this topic, "while there is a formal firewall between formal regulation of domestically-consumed and exported foodstuffs, there are a number of formal and informal pathways of influence". One of the main reasons to encourage local food safety reform was to make Indian goods more competitive with high-quality imports (Epstein, 2011), as India has gone through a period of successful growth and rising income that has enlarged its middle class, which has higher demand for safer food.

The Indian case typifies what many middle income countries have gone through in their attempt to increase their exports to high income countries, and demonstrates the positive externalities on domestic food safety that can arise through export-oriented reforms. Such externalities may also arise through private sector actions to meet stringent food safety and quality regulations mandated in export markets, such as the cases of Kenyan fresh vegetable exporters and the Peruvian asparagus industry (Jaffee and Henson, 2004; Swinnen and Vandeplas, 2011).

China, another emerging economy, presents a different case, in which the pressure generated by serious public health incidents related to food safety, combined with pressure from the international community that imports Chinese food products, led to a reform that is still at an early stage. After a series of food safety incidents, the high-profile 2008 milk powder scandal proved to policymakers that a serious food safety reform was urgently needed.[12] Six babies died and around 290,000 people—mostly infants—were poisoned due to the consumption of milk powder adulterated with melamine, a toxic industrial chemical added to fake higher protein content (Xiu and Klein, 2010). The economic losses were so huge and the pressure from consumers and external governments were so strong that the Chinese government was forced to reform food safety regulation. The country passed a new food safety law—which was later updated in 2015—and took several regulatory measures, first in the milk industry and later on in other industries. However, food safety regulation has a long way to go in the country, as inadequate compliance and enforcement are still present in a country that struggles to modernize its food supply chains in its transition to a market economy (Jia et al., 2012; The New York Times, 2014; Forbes, 2016).

While food safety scandals that exposed serious public health issues contributed to major rapid changes in developed and some developing countries' food safety regulation, this does not seem to have been the case in many of the less developed countries. For example, even though the 2004 aflatoxicosis outbreaks in Kenya killed over 100 people who had consumed contaminated maize and exposed the severity of aflatoxin contamination prevalence in the country, the incident did not lead to major changes in local food safety policy. However, these outbreaks did have a huge impact on the international donor community that since then has increased the amount of grants and research to help control the serious food safety problem in the maize value chain in

[12] Some of the Chinese food safety scandals that occurred prior to 2008 include: the poisoned rice scandal, in which rice factories were found to be producing rice by polishing and whitening mouldy rice and mixing it with mineral oil; the hair solution scandal, in which soy sauce factories were found to be using hair dissolved by hydrochloric acid and water in the production of soy sauce; the colouring use scandal, in which rice noodle factories and a sugar factory were found to be using a bleaching agent to whiten the rice noodles and sugar; and the fake milk scandal, in which 70 babies died of malnutrition for consuming fake milk powder (Yongmin, 2004).

Kenya, which in turn also created pressure for local policy reform. This suggests that public health concerns alone may not be sufficient as a driver of major food safety policy change in less developed countries. The fact that these economies face many other competing public health issues (e.g. malaria, HIV) and have weaker institutional frameworks may help to explain this difference in governmental regulatory responses in the face of large food scares.

It is also worth analyzing the Latin American case, as the subcontinent includes countries with very different levels of development, and has become a large exporter of fresh produce to both developed and—increasingly—developing countries.[13] At the end of 2015, I conducted a survey of food safety directors and animal and plant health officials of 13 Latin American countries.[14] When asked if they believed that the governments of their countries were giving more importance to food safety than 20 years ago, all of them gave a positive answer. Further, when asked what they believed was the main reason that had encouraged the public sector to give more importance to food safety issues in their countries, 70% of them chose an export-related reason (government's intention to promote exports, pressure from food producers that want to export their products, and pressure from exporters that want to reduce export rejections caused by

[13] For instance, of the top 10 countries exporting fresh produce to the US, eight are in Latin America (Johnson, 2014). Also, from 2006 to 2009, Latin America's contributed 14% of world agricultural exports. It produced, for example, 70% of banana exports, 45% of coffee and sugar exports, 44% of beef exports, 42% of poultry exports and 33% of maize exports (Sennhauser et al., 2014).

[14] The survey was conducted at a seminar on Agricultural Health and Food Safety organized by the Inter-American Development Bank in Managua, Nicaragua in November 2015. Food safety directors and animal and plant health authorities (who have the responsibility of food safety regulation in most countries) responded a survey that aimed to assess the main changes experienced by their countries' food safety policies and their main weaknesses. Officials from Uruguay, Belize, Bolivia, the Dominican Republic, Nicaragua, Ecuador, Paraguay, Barbados, Chile, Jamaica, Argentina, Costa Rica and Peru answered the questionnaire. The other 20 Latin American countries did not have representatives at the seminar.

food safety reasons). The other 30% mentioned the government's interest in reducing cases of foodborne diseases as the main reason, but also chose export-related reasons for the second main reason that explained the increased importance of food safety regulation. Also, when asked if the food safety authorities in their countries paid more attention to the compliance with the regulations by exporting firms, 70% of the officials gave an affirmative answer.

These answers reflect the fact that being a large food exporting region, developed countries' food safety standards have had a huge impact in the modernization of food safety management in most Latin American economies. There seems to exist some level of agreement that food safety regulation of food consumed domestically is laxer than food meant for export. However, no studies or reports were found that analyze this difference or the possible positive spillovers that the improved regulation of food for export might have generated on the regulation of locally-consumed food. Despite the focus on exports among food safety regulators, Latin American exporters still face a significant number of food safety related rejections. Using data from INTradeBID, I calculated the total number of rejections from the US suffered by Latin American agricultural exports due to food safety reasons: in 2011, 2489 consignments were rejected by the US (containing mostly fruits, vegetables, fishery products and cereals). The data also shows that the most frequent reasons for these rejections were presence of bacteria, failure to comply with satisfactory hygiene standards, and presence of pesticide residues above the permitted levels.[15]

[15] https://www.intradebid.org/site/ (accessed in May 2015). The data shows the occurrence of rejection events, but it does not include information on the volume or value of rejected consignments.

In the process of improving their food safety policies, developing countries can benefit from the experiences of developed countries in their own reform processes. However, there are certain characteristics that are specific to the challenges faced by developing countries. For example, in the poorest countries in Africa, Asia and Latin America, when approaching food safety reforms governments need to take into consideration the large informal sector that dominates food systems, which is harder to regulate due to the small-scale nature of its activities and is generally unable to compete with the formal sector. While small informal activities may not comply with safe food production and handling regulations—when they exist—, they still play very important economic and social functions. Stricter food safety regulations, if not enforced gradually and possibly selectively, risk damaging the informal sector, on which the poorest typically rely, both for income and as a source of affordable food. Also, when there is competition between the informal and formal sectors in a food supply chain, regulatory efforts risk generating opposition between them, which can end up harming either or both sectors, consumers and production. Even worse, a regulation solely based on a market-based approach that encourages formal sector firms to reject the lower quality food could end up pushing the more unhealthy food to the informal sector, therefore exposing the poorer to greater health risks (Moser and Hoffmann, 2015; Grace et al., 2015).

The high quality and safety standards mandated in the current globalized economy set a very high bar for the large informal sector in poor countries. Developed nations' informal sector not only represents a smaller fraction of their economies (Kus, 2010), but also is in better shape to function in a more stringent environment (as far as food safety and quality standards are concerned). Hence, when facing modern food safety regulatory reforms, developing economies must deal with big tensions created by the coexistence of a modern formal sector and a large informal backward sector in food production and processing.

The case of dairy regulation in Kenya represents a successful story of how this regulatory challenge was handled in a food chain oriented to local consumption and presents an example of how the combination of public health concerns and politicians' intent to gain constituencies' approval can lead to local food safety reform in developing countries. In 2003, a "milk war" between large formal milk processors and small-scale informal (unlicensed) vendors of raw milk took place because processors believed they were being hurt by unfair competition and blamed the small vendors for selling adulterated milk. A popular new government in place in Kenya, that had previously announced its intention to harmonize the agricultural sector regulatory framework, was able to solve this tension between the two sectors, increase dairy production and help small vendors improve the safety of the milk they sold (Leksmono et al., 2006). This was achieved by allowing small vendors to legally transport and sell milk in licensed milk bars, which was previously considered illegal, and providing them support to improve hygiene standards. According to Leksmono et al. (2006), the Kenyan government chose this sector to implement a food safety reform because as the dairy sector was smallholder-based and offered large pro-poor economic benefits, it was an opportunity to be seen addressing important social and economic needs. Hence, in this case the driver of the reform—that comprised food safety reasons among others—was an internal factor.

In the case of Uganda, it is interesting to compare two different food value chains that were driven to food safety reforms by different factors. As in many other developing countries, the export-oriented fisheries sector went through a food safety regulatory reform due to the influence of developed countries’ market access requirements. Between 1997 and 2000, the EU placed three bans on Ugandan exports of Nile perch, the country's main nontraditional export product, on the basis of food safety concerns. This led to a large reform of food safety regulation of fish destined to the export markets, while fish destined to the local and regional markets were never subject to any regulation (Ponte, 2007). The joint effort of the regulatory agency and the local processing industry helped implement new regulations and procedures in order to improve hygiene at landing sites and build laboratory testing capacity (Kjaer et al., 2012). This led to a transformation of the Nile perch export industry in the country and enabled the resumption of Ugandan fish exports to the EU.

The Ugandan dairy sector—which solely sells to the domestic market—also went through a successful regulatory reform that led to a food safety improvement in the milk chain. In contrast to the fisheries sector, this reform was not motivated by the need to comply with foreign higher-quality standards to attain access to export markets. A regulatory governmental office (the Dairy Development Authority, DDA) was set up in 2000 and became an efficient well-funded agency that has managed to gradually implement a regulatory reform that has led to an improvement in the quality of milk sold by informal traders, who constitute 80 percent of the sector (Kjaer et al., 2012). Traders and farmers were persuaded to incorporate affordable technological improvements after a series of bans that prohibited the use of unsanitary practices. According to Kjaer et al. (2012), the success of the reform could be explained by the existence of support from both the formal milk processing sector (that saw unfair competition in informal traders) and the ruling political coalition (who themselves owned cattle), together with the gradualism of the implementation of the reform given the constant complaints from the informal sector. While the private interests of the elite appear to have been important in explaining some successful regulatory stories, particularly in Africa, private interests do not seem to have had a significant role in motivating reforms in developed countries, possibly because there is little to gain from increased regulation in the absence of competition from the informal sector.

After briefly reviewing the last century of evolution of food safety policy around the world, it should be apparent that the drivers that have led to reform in more advanced economies differ from the ones that have pushed more backward countries to implement change. While most developed economies have faced the first generation of food safety reforms more than a century ago, as well as the current wave of reforms, due to public health reasons in the context of increased food trade, most developing countries' motivation to modernize food safety regulation has been to comply with higher quality standards in order to gain access to markets in wealthier countries. Nonetheless, a common trigger of their reform processes is the need to deal with the challenges that more integrated economies create: the nationwide integration that developed countries had to face more than a century ago, as production and trade spread within countries; and the worldwide integration that has deepened in the last decades and that has pushed local food safety regulations into a path of greater global standardization.

In the process of reviewing several developing countries' experiences, I found other drivers, aside from the need to comply with rising food safety standards, that have also motivated food safety reforms in certain local food value chains: i) to be able to compete with higher quality food imports (e.g. Indian case); ii) to regain credibility among the local population as well as decrease cases of foodborne disease after high profile food safety scandals (e.g. China's case); iii) pressure for reform from the international donor community working on food safety topics in the country (e.g. Kenya's case); and iv) to provide economic benefits to influential political stakeholders (e.g. dairy sectors in Kenya and Uganda). Even though this list is necessarily incomplete, it provides hope that food safety reforms in developing countries can also improve the quality of food locally consumed in these countries, especially by the poorest that have no access to formal domestic markets (e.g. supermarkets that mostly serve the middle and upper classes).

2.2 Research on demand for safer food in the developed and developing worlds: differences in topics studied and some key findings

Agricultural economics research has accompanied the differential evolution of food safety policy described in the previous section by picking different topics and answering different questions in each of the two areas of the world. Here I focus on research on demand for safer and higher quality food, which is the topic of this dissertation.

The largest part of food safety research focuses on developed countries' concerns, and as food safety reaches higher standards in these countries, it is increasingly becoming part of the broader study of food quality.[16] Many authors have studied the effect on food

[16] The term "food quality" encompasses several food attributes that can be grouped in subsets, such as: food safety, nutrition (e.g., fat, vitamins), value (e.g., appearance, taste), packaging (e.g., labeling), and production and processing practices (e.g., organically produced, irradiated) (Hooker and Caswell, 1996; Roe and Sheldon, 2007). Food safety attributes include foodborne pathogens, heavy metals, pesticide residues, food additives, naturally occurring toxins and veterinary residues (Henson and Traill, 1993). Because some food safety attributes are intrinsically linked to other food quality characteristics, the definition of what is considered food safety research has some degree of flexibility. For instance, pesticide residues above a certain

demand of different food safety attributes, such as levels of microbial pathogens, pesticide residues, and most recently the use of biotechnology and antibiotics and hormones in animals meant for food. Unnevehr et al. (2010) review several papers that study these topics in developed countries and conclude that demand for food is heavily influenced by food quality attributes—food safety included—aside from food prices and income.

A connected area of research focuses on the impact of information related to food safety and health on food demand and consumer welfare. Information can help reduce market failures such as information asymmetries between producers, intermediaries and consumers, and therefore influence consumers' valuation of food. Amid different ways of providing information, the most studied have been the use of food labels, government and third-party certifications, process and product performance standards and information campaigns. Most of these studies show that the provision of information can help align choices with preferences and hence lead to welfare gains. For example, Mazzocchi et al. (2004) prove the existence of welfare gains when timely food safety information is provided in the event of food scares, using data from an episode related to "mad cow disease" in Italy. The authors estimate a measure of consumers' cost of ignorance by comparing the utility derived from informed choices with the utility of uninformed choices, based on the concerns suffered by consumers given their inability to adjust their consumption behavior while the information was not disclosed. Also, Teisl et al. (2001) conclude that nutrient labeling together with an information campaign to educate US consumers affect consumers' purchase behavior and can lead to welfare gains.

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limit can clearly be a food safety issue, while organic production in general can be considered a different food quality feature.

There is a related large body of work that aims to measure willingness to pay for food with specific quality and safety attributes, using different preference elicitation techniques such as stated preference methods (e.g., contingent valuation and conjoint-based techniques) and revealed preference methods (e.g., experimental auctions and hedonic pricing). The development of these techniques has made a large contribution to the economics literature in terms of providing ways to estimate implicit prices of goods and attributes for which there are no markets. For instance, using a stated preference method to estimate willingness to pay for beef, Loureiro and Umberger (2007) show that US consumers value certification of USDA food safety inspection more than other attributes, such as country-of-origin labeling and traceability.

All these lines of research are mostly focused on developed countries, either through the development of theoretical models that capture food safety topics that pertain to these countries' realities, or through empirical applications that use data from higher income countries. When it comes to food safety in developing countries, the existent literature is much scarcer and has a strong focus on the impact of developed countries' food safety standards on developing countries' exports and income (Henson et al., 2000; Otsuki et al., 2001; Henson and Reardon, 2005; Jaffee and Masakure, 2005; Henson and Jaffee, 2008; Asfaw et al., 2009). Unnevehr and Ronchi (2014) present a literature review of recent papers that focus on this topic, most of which analyze the impact of industrialized countries' public and private food safety standards on several outcomes, such as: bilateral trade flows; the existence of benefits for specific exporting value chains in developing countries; and whether smallholder farmers and small firms benefit from participating in high-value food chains affected by such standards. Unnevehr and Ronchi

(2014) conclude that there is solid evidence showing that developing countries obtain market access benefits from compliance with food safety standards, and that there is some preliminary evidence of possible spillovers for domestic health and productivity. An important caveat is that most of the literature reviewed by Unnevehr and Ronchi (2014) centers on the small market of horticultural products for export to the EU, so their conclusions may not be generalizable.

Because most of this research centers on poor countries' food production that is meant to be consumed abroad, the studies don't aim to estimate local demand for safer food. Unnevehr and Ronchi (2014) conclude that "while much of the literature on impacts of food safety regulation in developed countries focuses on public health, in poorer countries the emphasis is on economic development". This is why most of these studies on developing economies focus on comparing compliance costs with market access benefits, leaving aside local public health benefits.

However, there is a relatively new and extremely thin literature that focuses on the existence of demand for safer food within developing economies (Ortega et al., 2011; Ifft et al., 2012; Birol et al., 2015; De Groote et al., 2016). These studies—that are reviewed in more detail in the following two chapters—find that there exists demand for safer food in the studied settings, which include a supermarket serving middle-upper classes in India, wet markets and supermarkets in urban China, and rural and informal market settings in Vietnam and Kenya, respectively.

The fact that only recently some studies have focused on the impact of local food safety regulations within developing countries is not surprising after the historical review presented in the previous section. On top of the fact that in many developing countries modern food safety regulation is a recent phenomenon, this lack of studies can be further explained by additional factors. First, in poor countries much of local food trade takes place in informal markets, in which actors' incentives are harder to predict given the lack of regulation and monitoring, and in which food origin is harder—or even impossible—to trace. Second, among consumers in developing countries there is less awareness of health risks in general, and food safety threats in particular, and this worsens the fact that food poisoning symptoms and consequences can easily be confused with other health problems. This lack of awareness about food safety hazards also implies that there is usually little pressure from consumers demanding that resources be devoted to understanding and fighting these hazards. Finally, due to the pressing food shortage in developing countries, there's some belief among the development community that food safety should be of concern at a later stage in the development process (i.e., food availability comes first). Due to all these factors, many questions remain unanswered in this field. This dissertation aims to contribute to this literature, focusing on the factors that influence the demand for safe staple food locally consumed in poor countries.

Chapter 3: Traders' demand for maize quality and safety in informal markets[17]

3.1 Introduction

Enforcement of food safety regulations is often weak in developing countries, particularly within markets for locally consumed food. Because food safety comprises mostly unobservable characteristics, the absence of certifications and information labels in these settings leads to uninformed consumption choices that can have negative health consequences. Maize quality comprises both observable attributes (e.g., kernel size, presence of broken grains, insect damage, etc.) and unobservable or difficult to observe attributes, such as aflatoxin contamination and moisture content. Because aflatoxin contamination makes maize consumption extremely harmful to human health, making this attribute observable is important for public health reasons.

High moisture content in maize can allow the growth of molds, which affects taste and can also lead to aflatoxin contamination. The fact that moisture and aflatoxin content are difficult to observe implies that they are not adequately rewarded in the market, hence discouraging the production and sale of higher quality maize. Therefore, transforming these unobservable characteristics into observable ones has the potential to strengthen the link between healthfulness and price in the maize value chain in Kenya. This in turn could create incentives for farmers and traders to invest in farming, handling and trading practices that increase the availability of safe food. Because measuring grain moisture

[17] This research was funded with resources from the University of Maryland's ADVANCE Seed Grant Program 2011-2012.

content is much cheaper than testing for aflatoxin, the provision of moisture content information could potentially be a more cost-effective policy tool than aflatoxin testing.

Previous work conducted in similar settings provides some evidence that maize quality information is valued by consumers. Hoffmann and Gatobu (2014) show that Kenyan smallholder farmers were willing to pay over 21% more for their self-produced maize than for maize procured from local markets, and providing information on the safety of market-sourced maize reduced this gap. This suggests that farmers may have some private information about the quality of the maize they produce, and they realize as well that they do not have the same type of information on maize grown and traded by others. Another study shows that maize that has been purchased is more likely to be aflatoxin contaminated than self-produced maize, indicating that marketed maize is on average of inferior quality (Hoffmann et al., 2013). These results imply that the limited observability of maize safety may create asymmetric information problems in this market.

In this study, I explore whether the provision of food quality information that would otherwise be hard or impossible to assess in this setting leads to a price premium. Hoffmann et al. (2013) show that observable maize attributes, such as the presence of rotten and broken grains, have a negative effect on price, but unobservable attributes, such as aflatoxin contamination, does not. This coincides with the results of a survey conducted by Nyoro et al. (1999) that covered 200 traders of different types in several towns across Kenya. These traders reported that quality differences, such as color, size of kernels, and amount of foreign material, are distinguished by eyesight and used as the main criteria determining quality and price. However, the extent to which prices currently respond to maize moisture content is not clear. This attribute may be partially observable to small traders and consumers, who do not have access to moisture meters, but can use simple methods such as biting and feeling grains to assess moisture.

Using a framed field experiment, this research explores whether traders are willing to pay more for maize labeled as having lower moisture content and allowable levels of aflatoxin, and whether this depends on their ability to sell it at a premium in the market. The research design also allows examination of whether moisture content information is in fact unobservable for traders, or if they are already able to observe this attribute. To answer these questions, 369 traders from different markets across Kenya were invited to participate in a second-price sealed-bid auction in which information on moisture content and aflatoxin contamination of maize auctioned was varied experimentally using labels.

Several studies have used field experiments to investigate consumers' willingness to pay for more nutritious food in developing country contexts where malnutrition is severe (Masters and Sanogo, 2002; Stevens and Winter-Nelson, 2008; Naico and Lusk, 2010; Chowdhury et al., 2011; De Groote et al., 2011). However, there are extremely few studies that have focused on willingness to pay for food safety attributes in developing countries (Ifft et al., 2012; Birol et al., 2015). The closest study is the one by Ifft et al. (2012) that assesses willingness to pay for chicken labeled as safely produced in an informal market setting. The study concludes that consumers were willing to pay a 10-15% premium for safer chicken. No study was found that attempted to assess willingness to pay for food safety among traders in informal market settings, instead of consumers. The advantage of focusing on traders is that they represent the closest link to farmers, who have a key role to play in improving maize quality.

In addition, this research investigates the role of traders in preserving or diminishing maize quality once it leaves the farm gate. Given previous findings, it is unclear whether the quality differential between homegrown and traded maize arises prior to sale, through farmers' post-harvest practices and sorting behavior, or during transport and storage by traders. Previous studies focusing on maize traders are extremely few, possibly because their mobility and time constraints during market days make it challenging to interview them. Hence, not much is known about the practices, knowledge or incentives of traders as these relate to maize quality and safety.

Even though reliable technologies for measuring moisture content are out of the reach of most informal traders, it is much cheaper to test moisture than aflatoxin, so from a policy perspective it may have more potential for large-scale implementation. More accurate information on maize moisture content could potentially enable small-scale traders to target drier maize to buyers who are willing to pay a premium for higher quality maize. These could be formal buyers, such as the National Cereals and Produce Board (NCPB) and large millers, who have the technology to test for moisture content and are thought to pay higher prices. Also, customers may be willing to pay a premium for maize if they are better able to assess its quality. This premium for drier maize could be expected to pass all the way back to farmers, thus encouraging them to adopt more careful storage and drying practices which would in turn reduce the risk of fungal growth and aflatoxin contamination.

3.2 Context

Ways to prevent crop contamination include both pre-harvest and post-harvest practices such as selection of drought-resistant and pest-resistant seeds, thorough drying and careful storage of crops, and removal of visibly moldy grains.

Human exposure to aflatoxins occurs through ingestion of contaminated food, and consumption of milk or meat products from animals raised on contaminated feed. Chronic exposure to aflatoxins has been associated in several studies with severe health effects such as liver cancer, depressed immune response and growth faltering among children (Turner et al., 2003; Williams et al., 2004; Strosnider et al., 2006; Shephard, 2008). Ingestion of large amounts of aflatoxin contaminated food can even lead to death.[18] It has been estimated that more than 5 billion people in developing countries worldwide are at risk of chronic exposure to aflatoxins through contaminated foods (Williams et al., 2004; Strosnider et al. 2006; Khlangwiset et al., 2011).

Aflatoxin contamination cannot be detected by eye. Certain visible characteristics are associated with its presence, including rotten, moldy and discolored grains, unpleasant smell and bitter taste. However, none of these characteristics are exclusive to aflatoxin contamination and they are not always present in contaminated maize. This makes aflatoxin contamination mostly unobservable.

[18] In 2004, rural Kenya witnessed one of the largest aflatoxicosis outbreaks ever, which was caused by aflatoxin-contaminated maize and resulted in 317 cases and 125 deaths (Lewis et al., 2005). The affected area was the Eastern Province, which had had a previous aflatoxicosis outbreak in 1981, that killed 12 (Ngindu et al., 1982). In 2010, aflatoxin contamination rendered at least 2.3 million bags of maize unfit for human and livestock consumption, and led Government officials in Kenya to offer to buy the contaminated maize in an effort to keep it off the market (Africa Online News, June 2010).

High moisture content is a necessary condition for fungal growth, which is in turn necessary for the production of fungal toxins such as aflatoxins. Since high moisture content is correlated with the fungus that produces aflatoxin, as well as many other fungi, moisture content serves as a good indicator of taste, and a less perfect, but still useful, warning sign of potential aflatoxin contamination (Oyebanji and Efiuvwevwere, 1999). Although very high levels of moisture can be observed by feel, the same is not true for lower levels of moisture content at which fungi are able to grow. The Kenyan regulatory standard sets the maximum allowed moisture content for maize grains at 13.5%. In order to accurately assess the percentage moisture content in maize, a grain moisture meter must be used. The simplest maize moisture meter costs around USD 80, and more precise ones can be much more expensive. This puts accurate moisture testing out of reach for small-scale traders and farmers, whose annual income per capita at the time of the study was around USD 900.[19] However, testing moisture content is much cheaper than testing for aflatoxin. Moisture meters can be used for many years, so the cost per test can be very low. Formal sector buyers test the moisture content of grains, and in general reject maize with moisture content above the standard of 13.5% (Nyoro et al., 1999). On the other hand, this regulation is not enforced in informal maize markets. There is anecdotal evidence that water is sometimes added deliberately to the grains before sale in order to increase the weight of the grain, leading to higher moisture content (USAID, 2011). Small-scale traders and consumers, who do not have access to moisture testing technology, use less accurate methods, such as biting and feeling the grains, to assess the humidity of the grains they purchase.

[19] In Kenya, the adjusted net national income per capita (in current USD) in 2011 was USD 912 (World Bank, World Development Indicators).

The maximum aflatoxin content allowed in maize intended for human consumption by Kenyan regulatory standards is 10 ppb (parts per billion). However, enforcement of this regulation is highly imperfect. Aflatoxin content in maize can only be determined by specialized tests that are prohibitively expensive for use on quantities typically traded in informal markets. The price of a rapid aflatoxin test appropriate for field use can range between USD 4 and USD 13 per sample. Aflatoxin laboratory tests are of much less practical use in the field, as samples must first be transported to the lab for testing. This explains why the aflatoxin regulation is not enforced in informal markets, which serve the vast majority of Kenyans. According to interviews with industry stakeholders, few if any formal sector buyers were testing grain for aflatoxin at the time data was collected for this study (Hoffmann V., personal communication, July 12, 2016). Those who currently test for aflatoxin—a share which has increased in the time since data was collected (see APTECA, n.d.)—do so at the mill gate at the level of the truckload.[20]

Estimates of aflatoxin prevalence in Kenya vary by area, year and role in the value chain. A study conducted between 2009 and 2011 as part of the Aflacontrol project shows that on average around 40% of maize samples from farmers' fields had contamination levels above the regulatory limit, and the rate was even higher for maize from farmers' stores and from markets (IFPRI, 2012). In terms of regional variation, samples in the Eastern province, a high aflatoxin risk area, had higher prevalence, as expected. One of the conclusions of this study is that storage practices seem to be an

[20] In theory, when maize imports arrive at the port, moisture and aflatoxin content are tested by the Kenya Bureau of Standards (KEBS) and the Kenyan Plant Health Inspectorate Services (KEPHIS). However, this does not seem to be the case according to what was mentioned in several interviews with different stakeholders in the country, and no data was found that would back up this assertion. In practice, private laboratories are sometimes hired to perform aflatoxin tests by formal sector buyers, but there is no government control over this (Kimani and Gruère, 2010; Kang'ethe, 2011).

important determinant of contamination, and that more research should be done on maize available at the markets.

Half of Kenya´s maize production is produced by small farmers who have on average 5 acres of cultivated land (Kirimi et al., 2011). This implies that changing maize cultivation and handling practices in order to reduce the risk of aflatoxin contamination would involve targeting a large number of farmers.

There are different types of maize traders in Kenya and they can be classified into the following categories: wholesalers, assemblers, dis-assemblers, retailers, posho-millers and large millers (Nyoro et al., 1999). Assemblers are usually the first purchasers of maize, as they buy maize from farmers and sell it to wholesalers, dis-assemblers and retailers. Assemblers are usually mid-size traders operating in a single town through stores or stalls. Wholesalers (also called lorry traders) buy mainly from assemblers in maize surplus regions during the harvest season and sell to milling companies or local retailers in deficit regions. Dis-assemblers buy maize mainly from large wholesalers in deficit areas and sell in reduced quantities to retailers and final consumers. Retailers buy from dis-assemblers, wholesalers or even farmers and sell in small quantities to consumers. Posho-millers are small operations to which consumers bring maize grains to have them ground into whole maize meal (posho) using a simple hammer-milling technology. Large millers use capital intensive roller-milling technology to process large amounts of maize, and they do their own packaging of maize meal products. Large millers mainly buy from wholesalers during the peak season and from NCPB stocks when maize is scarce.

This study focuses on small and mid-size traders offering maize grains for sale at open-air markets. Most of them were retailers, but there were also assemblers and dis-assemblers. A thorough description of the traders included in this study is provided in the Results section.

3.3 *Experimental design*

From September to November 2011, a convenience sample of 369 traders was recruited at nine open-air cereal markets across Kenya to participate in the study.[21] The markets were purposely selected in seven different agro-ecological zones, which have very different maize producing capacities and susceptibility to aflatoxin contamination. The study was timed to span several points in the maize harvest cycle. Variation in both timing and location leads to differences in maize supply, and thus prices. This variation is expected to impact the extent to which food quality and safety information is rewarded in the market, and thus traders' valuation of such information.

Three of these markets are located in the Eastern province (Gakoromone and Chuka in Upper Eastern, and Machakos in Lower Eastern), considered a high-aflatoxin risk and maize-deficit area. Two other markets are located in the Rift Valley province (Eldoret and Kitale) and are part of what is known as Kenya's grain basket, the high-potential maize zone, and thought to be a low-aflatoxin risk area. Two markets were selected in the Western province (Bungoma and Webuye), both maize surplus areas and thought to have low aflatoxin prevalence. Finally, the last two markets are in the Nyanza province (Kisii and Kisumu), which although it has traditionally been considered a low-aflatoxin risk

[21] Because market managers could not provide us with a roster of traders selling at the market, and because traders' presence at the market was impossible to predict, it was not possible to use a random sampling strategy.

area, a recent study by IFPRI (2012) shows high levels of contamination in parts of this province (particularly in Kisii). Table 1 presents the list of markets covered in the study and summarizes their main characteristics.

In terms of timing of the study, some markets were visited before the harvest season, others during the main harvest season, and others during the lean season. The study was conducted over three rounds, and each round covered three markets in very different parts of the country, which were in different points in their maize cycle. As shown in Table 1, this is reflected in the average prices of maize for sale at these markets. The average 90KG and 1KG prices in each market were calculated from the surveyed traders' asking prices at the time of data collection.

Table 1: Main characteristics of markets selected for the study

Market	Province	Agro-ecological zone	Types of maize producing area	Dates visited	Season timing	# Traders surveyed	Avg 1KG Price (Ksh)	Avg 90KG Price (Ksh)
Gakoromone	Eastern	Central Highlands	Deficit area	Sept 1-2	Lean season	39	42	3579
Eldoret	Rift Valley	Lower Highlands	Major surplus area	Sept 6-7	Lean season	38	46	3428
Bungoma	Western	Western Transitional	Surplus area	Sept 8-9	Harvest season	39	38	2800
Chuka	Eastern	Central Highlands	Deficit area	Oct 10-11	Lean season	39	46	3818
Kitale	Rift Valley	Upper Midlands	Major surplus area	Oct 14-15	Harvest season	40	32	2611
Webuye	Western	Western Transitional	Surplus area	Oct 18-19	Harvest season	38	34	2715
Kisii	Nyanza	Western Highlands	Deficit area	Nov 15-16	Lean season[1]	56	47	3799
Kisumu	Nyanza	Western Lowlands	Major deficit area	Nov 18-19	Lean season[1]	40	43	3427
Machakos	Eastern	Eastern Lowlands	Major deficit area	Nov 22-23	Lean season	40	45	3717
TOTAL						**369**	**41**	**3322**

[1] Poor harvests due to bad weather in these regions

At the markets, traders were approached at their stalls by the enumerators and invited to participate in the study, which was simply described as "a study about maize in Kenya". They were briefly told what they would be asked to do, and that if they agreed to participate, at the end of the study they would be given KSh 500 (equivalent to approximately USD 6) in compensation for their time.[22] Those who agreed to participate were first interviewed to obtain information about their trading activities, their sorting, transporting and storage practices and their knowledge about aflatoxin and maize moisture content. Those traders who did not know the moisture content regulation were read a script with a brief explanation, as knowing the regulation could have a direct impact on their bids.[23] Also, all traders were read a script with a short explanation of what a moisture meter is, as this was also important for them to be able to grasp the information that would later be provided in the auction area.[24] The goal was to give all traders adequate context to make sense of the information that would later be provided.

In addition to survey data, enumerators took samples of each trader's maize (one of each different quality they had for sale) in order to assess its moisture content. 98% of the participating traders had only one type of maize for sale. After the survey, traders were invited to participate in a second-price sealed-bid auction for six bags of maize grain that took place in a secluded area of the market. The maize bags were 90KG, which is the usual unit of measure in Kenya for large maize transactions. At the auction, traders were shown six maize bags: two had "low moisture content" (less than 13.5%, i.e., in compliance with the regulation); two had "medium moisture content" (between 14 and

[22] Participating in our study took approximately an hour of traders' working time, as the survey had to be interrupted every time a customer arrived. Also, it implied having to leave their stall unattended while they were in the auction session. Therefore, a monetary compensation had to be offered in order to induce traders to participate.

[23] If traders knew the maize moisture content regulation, it was emphasized to them that they were right and a script was read to make clear that moisture content higher than 13.5% did not comply with the regulation. Traders who acknowledged not being aware of the moisture content regulation, were read the following script: "The maximum moisture content allowed by NCBP is 13.5%. This means that if maize has higher moisture than this, it is not complying with the regulation".

[24] All traders were read the following script: "A moisture meter is a device to measure the level of moisture in maize. When you use it, the tool gives you a number that tells you how dry your maize is".

15%); and two had “high moisture content” (between 17 and 19%). The bags that shared the same moisture content belonged to the same batch.[25]

Five out of six traders (83% of the sample) were exposed to the “moisture information treatment” (MIT), which consisted of receiving the moisture content information for only one bag in each moisture pair. Information on moisture content was provided through large labels that were affixed to the 90KG maize bags. In other words, for each moisture content pair, one of the bags was marked with a label containing its moisture content range, and the other bag of the pair was not labeled.[26] Every sixth trader (17% of the sample) was exposed to the “aflatoxin information treatment” (AIT), in which labels (for low and medium moisture pairs only) contained information on compliance of the maize with the aflatoxin regulation. The other two bags of each of these pairs were unlabeled. The tests for aflatoxin were conducted using rapid aflatoxin test strips (RIDA®QUICK Aflatoxin) according to manufacturer instructions. These tests do not require specialized skills to be conducted and produce quick results. In the AIT, both high moisture content bags had no information labels because they had not been tested for aflatoxin. Given the high correlation between moisture and aflatoxin contamination, it would have been challenging to find high moisture maize bags that were not contaminated. The reasons for keeping the two unlabeled high moisture bags

[25] The auctioned maize bags had been previously purchased in a different market from the one where the auction was taking place. When purchasing these bags, the seller was asked to bring a set of three bags that belonged to the same batch of maize he had purchased.

[26] The “moisture information treatment” (MIT) labels used read: “Moisture content below 13.5%”, “Moisture content between 14 and 15%”, “Moisture content between 17 and 19%”.

was to have a similar auction setting in the AIT as in the MIT, and to assess traders´ ability to recognize high moisture bags and their willingness to pay for these.[27]

The bags that shared the same moisture content belonged to the same batch, and hence the maize contained in those bags was also similar in all observable characteristics. This was important in order to be able to attribute the differences in bids between bags in the same moisture range to differences in the information provided. In order to account for any possible observable difference in quality between the bags in the same moisture content pair, the label was switched between bags of the pair every other trader. Enumerators were trained to be extremely careful not to be seen by traders when switching the labels.

When the trader arrived at the maize auction area, the auction rules were explained to her. A piece of paper was handed in to her, where she would have to write down the amount of money that she was willing to pay for each of the six maize bags. The bags' labels were read out loud, to make sure that everybody understood the information that was being provided. Traders were told that one of the six bags would be sold at the end of the day, and the trader that had bid the highest for that bag would win the opportunity to buy it. The winning trader would pay the second highest price among the bids entered for that bag. The bag to actually be sold would be randomly chosen through a draw. If traders didn't understand or didn´t take seriously that there was a positive probability that they would have to buy one of the auctioned maize bags, their bids would not reflect their true willingness to pay. Hence, in order to minimize the risk of having the winner of a bag be unwilling to buy it, it was explained to traders that if they won the auctioned bag, their

[27] In the "aflatoxin treatment information" (AIT) the labels used read: "Tested for aflatoxin: complies with regulation".

compensation of 500 Ksh for participating in the study would be used toward the price of the bag. If they decided not to buy the bag, they would lose this compensation.

Before starting the bidding for the bags, two practice rounds of bids for a pencil were conducted. After each practice round, traders were asked comprehension questions to test if they had understood the rules. If they had not understood, another practice round was conducted. This continued until the correct answer was given. After the first practice round, 72% of traders answered comprehension questions correctly, and after the second round, an additional 24% of traders demonstrated understanding of the auctions rules. This quick understanding could be explained by the fact that the sample consisted of experienced business people, the majority of whom had prior knowledge of auctions. In the survey 64% of traders said they knew what an auction was and 15% said they had participated in an auction before.

Before submitting their bids, traders were allowed to inspect each bag as much as they wanted, as would be the case in a real market transaction. After the trader had written down the six bids, the piece of paper was put inside an envelope and it was set aside to be opened at the end of the day, with all the other bids.

The goal of using a second-price sealed-bid auction was to have in place an incentive compatible mechanism that would elicit traders' true valuation of the different maize qualities when otherwise unobservable information was provided. The second-price auction method was chosen over other revealed preference methods (take-it-or-leave-it offers at random prices or TIOLI, and the Becker Degroot Marschak mechanism or BDM), for more closely mimicking actual transactions compared to the BDM while providing more precise willingness to pay estimates than a TIOLI methodology.

3.4 Results

3.4.1 Traders´ knowledge and practices

Table 2 summarizes the main characteristics of the 369 traders in the sample who, on average, were in their mid-thirties, had 8 years of formal education and had been in the maize trading business for less than a decade. In terms of size of their trading business, most of these traders can be considered "small", as 66% of them usually sold maize in 1KG and 2KG units, and very few (12%) had ever sold to a formal buyer such as NCPB or a large miller. Also, most traders reported actively investing in the quality of maize in their possession: almost three quarters reported covering their maize during transport to protect it from rain (in polythene or in covered vehicles); a similar proportion reported sometimes drying and sorting the maize they purchased; and a quarter reported adding preservatives to their maize. Among those traders who reported using preservatives, more than half said they used the most common local insecticide for stored grain called Actellic.

The majority of traders in the sample regularly sourced their maize from farmers: 62% purchased only from farmers, 22% only from traders, and 15% from both farmers and traders. In terms of maize origin, 66% of traders usually bought maize that had been locally grown. This is not surprising given that if traders were mostly sourcing from farmers, it is reasonable to expect the latter to be local farmers, as this reduces transportation costs.

When it comes to maize sourcing preferences between types of farmers, the fraction of traders that preferred sourcing from small farmers doubled the fraction that instead preferred large farmers. The most mentioned reason for preferring small farmers was the good quality of their maize; the most mentioned reason for preferring large farmers was the lower price of their maize; and traders were most frequently preferred for being a reliable source of maize. These responses are in line with previous findings that have highlighted the belief among the local population that maize bought directly from farmers should be of higher quality than maize bought from traders (Hoffmann and Gatobu, 2014). These answers also show that there seems to be a belief—at least among traders—that the smaller the farmer, the higher the quality, as probably it is thought that smaller farms produce maize for sale following similar better farming, drying and storage practices to those employed to produce maize for own consumption.

Half of the sample declared selling higher quality maize to different buyers from those to whom they sell their lower quality maize. Interestingly, almost all of these traders (44% of the whole sample) said they sold the higher quality maize to individuals, and only 4% of the sample said they sold the higher quality maize to formal buyers. Therefore, there could be some degree of reputation effect going on in these informal markets, in which customers tend to be recurring and traders try to keep their loyal customers through the sale of high quality maize.

Table 2: Mean characteristics of traders in the sample

Trader's Characteristics and Background	
# Traders	369
Female	82%
Age (years)	37
Years of education	8
Years in maize trading	8
Trading Activities: Purchases and Sales	
"Small" traders: usually sell in 1KG or 2KG units	66%
Source maize only from farmers	62%
Source maize only from traders	22%
Source maize both from farmers and traders	15%
Source maize locally grown (same town where traders operate)	66%
Sell only to individuals	25%
Ever sold to traders	59%
"Large" traders: only sell to traders, millers & schools	2%
Ever sold maize to formal buyer (NCPB or large miller)	12%
Had maize tested for moisture in at least 1 of the 3 last large purchases	5%
Maize quality	
Most mentioned maize characteristic looked for when purchasing	Dryness
Sell high quality and low quality maize to different buyers	53%
Sell high quality maize to formal buyer (NCPB or large miller)	4%
Sell high quality maize to individuals	44%
Sorting, Transportation and Storage Practices	
Need to transport purchased maize	94%
Cover maize during transport to protect it from rain	73%
Dry purchased maize	69%
Sort purchased maize	66%
Number of days that maize is stored	19
Add preservatives to their maize	22%
Acknowledge having had low quality maize (went bad while stored or was purchased accident	48%
When they have bad maize they mix it with good maize and sell it	20%
When they have bad maize they sort it and sell it at a lower price	14%
When they have bad maize they throw it away	12%
When they have bad maize they grind it and feed animals	2%
Had maize spoilage losses during current or previous season	15%
Personal Preferences	
Prefer to buy maize for business only from farms	65%
Prefer to buy maize for business only from traders	21%
Grow own maize for own household consumption	56%
Get maize from store for own household consumption	20%
Aflatoxin Knowledge	
Have heard of aflatoxin	79%
Gave a correct definition of what aflatoxin is	74%
Know aflatoxin is harmful for human health	75%
Know aflatoxin is linked to maize moisture	17%
Can tell if maize is contaminated observing its color	68%
Own maize traded in the past could be aflatoxin contaminated	28%
Think there may be contaminated maize in market on the survey day	8%
Moisture Meter Knowledge	
Know what a moisture meter is	49%
Have ever used a moisture meter	7%
Have every seen somebody using a moisture meter	37%
Own a moisture meter that works	1%
Think a moisture meter would help them better assess quality of maize	94%
Know that maxiumum moisture content allowed by NCPB is 13.5%	16%

Almost half of the traders admitted having had at some point maize that went bad during storage or having purchased low quality maize accidentally. Among these traders, 43% said that when this happened they would mix the low quality maize with the higher quality maize; 30% said they would sort out the low quality maize and sell it at a reduced price; 20% said they would throw it away; and 4% said they would grind it and use it as animal feed. Two other studies mention the mixing of different maize qualities and the grinding of rotten maize for animal feed, as practices commonly used in this food chain (IFPRI, 2010; Kang'ethe, 2011).

In line with previous findings, more than half of the sample stated that for own household consumption they preferred to grow their own maize, and among these traders almost all of them (93%) stated that the reason for this was the good quality of homegrown maize. This stands in sharp contrast with only 20% of the sample that preferred to get maize from their own business for own household consumption. This provides more evidence of the existence of a widespread belief—even among traders—that maize available for purchase is of lower quality than homegrown maize. Also, contrary to what was expected, three quarters of the surveyed traders said they preferred to buy maize for own household use from their own province; and this was particularly true for traders in the Eastern province—the area with the highest aflatoxin contamination rates in the country—, 92% of whom reported preferring to buy maize from the Eastern province for their families' consumption. This could be explained by the lack of awareness of the prevalence and geographical spread of aflatoxin contamination in the country, as well as by the subjective belief that local produce ought to be of better quality.

Turning to unobservable maize characteristics, three quarters of traders in the sample gave a reasonably accurate explanation of what aflatoxin is, but only 17% linked aflatoxin to maize moisture, thus showing a generally weak understanding of what factors cause these toxins.[28] Half of the sample knew what a moisture meter is but only 16% knew the maize moisture content regulation. Thirty seven percent of traders had ever seen somebody use a moisture meter, confirming that the majority of these traders were selling retail to individuals rather than to formal sector buyers.

Maize samples were purchased from the surveyed traders. These were obtained from six different points inside traders´ large maize bags using a probe, in order for the sample to be representative of the whole bag. These maize samples were tested for moisture content using a calibrated maize grain moisture meter. The meter used was a resistance moisture meter, which is the type that requires a ground sample of maize and measures the kernel's external and internal levels of moisture, and is therefore believed to be more accurate (USAID, 2011). The moisture content recorded for each maize sample was the average of three different readings, making the moisture content recorded more precise. Table 3 shows the moisture content of 353 maize samples, grouped in percent moisture ranges. Only 15% of the maize samples were below the regulated level of 13.5% moisture content, and more than a third of the samples had more than 15% moisture content. This confirms the lack of enforcement of this regulation in the informal markets. Further, the sampled maize moisture content distribution shows that the maize bags that were auctioned had moisture content in the moisture ranges that traders in this

[28] Traders´ own definitions of aflatoxin that included terms such as "moldy grains", "rotten grains", "poisonous maize" or "maize not well dried" were considered accurate responses.

study were used to having in their own maize.[29] Given that the Eastern province is a high aflatoxin risk area, it was of particular interest to check if the distribution of moisture content test results from maize samples procured in this region showed a higher proportion of high-moisture samples. However, Table 3 shows that the fraction of samples procured in the Eastern province that are above the recommended level is as high as in the other regions (even slightly smaller).

Table 3: Moisture content in traders' maize samples

% Moisture Content Range	All		Only Eastern	
	# Samples	%	# Samples	%
Below 13.5%	54	15%	22	19%
Between 13.5 and 15%	171	48%	58	50%
Between 15 and 17%	104	29%	33	29%
Above 17%	24	7%	2	2%
TOTAL	**353**	**100%**	**115**	**100%**

In order to assess whether moisture content had any effect on maize price, traders' asking prices at the time of the study were regressed on the moisture content of the samples taken from maize they had for sale. Separate regressions were run for the 1KG and 90KG asking prices, in order to assess whether the retail price was more sensitive to differences in quality, given that customers might find it easier to assess the quality of a 1KG bag than a 90KG bag. Also, separate regressions were run by season in which the data collection took place at the trader's market: lean season or harvest season. The four regressions were run using market fixed effects to account for the large variation in prices

[29] No correlation was found between moisture content in traders´ maize and their transportation, sorting and drying practices. Given that we only have one observation of traders´ maize moisture content and that traders were not asked specifically about their practices in connection with the maize that was sampled, it was not surprising to find no correlation between these two.

across markets. Table 4 shows the results. Moisture content does not have a significant effect on either the 1KG or 90KG maize price during the lean season. However, moisture content has a negative effect on price during the harvest season, only significant at 10% level and for the 90KG asking price. It is reasonable to expect that when maize is more abundant during the harvest season, buyers might be more selective and hence penalize more humid maize. This result shows that price penalties—when they exist—are more sensitive to quality in the season of abundance of grain, and coincides with what was found by Jones et al. (2014) in informal dry bean markets in Rwanda. Still, the lack of a significant effect of moisture content on price in most of the cases analyzed in Table 4 provides evidence of the weak observability of moisture content in this setting, which potentially prevents traders from obtaining a premium for offering dryer maize.

Table 4: Effect of moisture content on maize prices by season (OLS)

	Lean Season		Harvest Season	
	90KG Price	1KG Price	90KG Price	1KG Price
Moisture Content (%)	1.27	0.16	-8.57*	0.01
	(15.11)	(0.22)	(4.59)	(0.13)
Constant	3,634***	42.95***	2,838***	34.49***
	(222.24)	(3.28)	(70.74)	(2.02)
Observations	241	239	114	115
Number of Markets	6	6	3	3
Market fixed effects	Yes	Yes	Yes	Yes
R-squared	0.000	0.002	0.031	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.4.2 Impact of information on willingness to pay

Table 5 presents summary statistics of traders' bids by type of maize bag, for the 309 traders (84% of the sample) that were subject to the "moisture information treatment" (MIT). The average bids for low moisture maize, both without label and with label (A and B), are higher than the average bids for medium moisture maize bags (C and D), which in turn are higher than the average bids for high moisture maize bags (E and F). This suggests that traders are able to assess maize moisture content with their own methods when no information is provided (A, C and E): the average bid decreased as the level of moisture content increased. Also, traders seem to trust the information provided to them through the labels, and to adjust their bids accordingly. When information on moisture content was provided for the low moisture level maize (B)—the only lot that complied with the regulation—the average bid was higher than when no information was provided (A); and when information on moisture content was provided for the medium and high moisture levels (bags D and F, which did not comply with the regulation), the average bids were lower than when no information was provided. Table 5 also shows the percentage of traders that bid zero for each of the maize bags. Almost none of the traders did so in the low and medium levels of moisture content, and around a quarter of the sample bid zero for the high moisture content pair of bags (E and F), again providing evidence of both the ability of traders to assess moisture content to some extent and their reaction to more precise information on this quality attribute.

Table 5: Summary statistics of traders' bids by maize bag type in the MIT

	Low Moisture-Unlabeled (A)	Low Moisture-Labeled (B)	Medium Moisture-Unlabeled (C)	Medium Moisture-Labeled (D)	High Moisture-Unlabeled (E)	High Moisture-Labeled (F)
Mean (KSh)	2,867	2,945	2,702	2,634	1,940	1,887
Std Deviation (KSh)	548	543	587	638	1,129	1,167
Median (KSh)	3,000	3,100	2,900	2,900	2,200	2,400
% 0 bid	1%	1%	2%	2%	22%	25%
# Observations	309	309	309	309	309	309

Low moisture <13.5% (regulation compliant)
Medium moisture 14-15%
High moisture 17-19%

To check whether bids for the auctioned maize were consistent with traders' market behavior, average bids were calculated by market and compared with average 90KG prices recently paid for maize purchased by the surveyed traders in each market. The average prices paid for 90KG bags were estimated using the most recent purchase made in the same month that the survey was conducted, to minimize the impact of seasonality on prices. The average prices paid were also calculated using the last 3 purchases made in the same month that the survey was conducted, and the results were almost identical (not included in Table 6). In order to calculate an average bid per market that could be compared with the average price paid, the average bids for each unlabeled bag in the 3 moisture ranges were weighted by the proportion of tested maize samples in each of these moisture ranges in each market. The difference between prices and bids is small and not significant, with the overall average bid approximately 7% below the average price paid in the last purchase of maize, and as little as 3% below in one of the markets (Table 6). This provides confidence that traders did see the auction as a real opportunity to purchase maize, similar to buying it from other sellers, and hence their bids expressed their true maize valuation.

Table 6: Average bids compared to average prices paid for purchased maize, by market

	Meru	Eldoret	Bungoma	Chuka	Kitale	Webuye	Kisii	Kisumu	Machakos	**Average**
Bids bag A - low moisture unlabeled (KSh)	3,246	3,139	2,355	2,974	2,169	2,356	3,300	2,978	3,204	**2,858**
Bids bag C - medium moisture unlabeled (KSh)	3,099	2,948	2,111	2,778	2,064	2,205	3,114	2,853	3,061	**2,693**
Bids bag E - high moisture unlabeled (KSh)	2,615	2,678	1,773	1,687	1,383	1,283	2,414	1,976	2,060	**1,985**
Weighted average bids (KSh)[1]	3,090	2,831	2,077	2,783	2,052	2,192	3,189	2,836	3,109	**2,684**
90KG price paid in most recent purchase (KSh)[2]	3,185	3,187	2,211	2,975	2,274	2,400	3,448	3,030	3,400	**2,901**
Difference (price - bid, KSh)	**95**	**356**	**134**	**192**	**222**	**208**	**259**	**194**	**291**	**217**
Difference (% of price paid)	**3%**	**11%**	**6%**	**6%**	**10%**	**9%**	**8%**	**6%**	**9%**	**7%**

[1] Average bids for A, C and E in each market were weighted by the proportion of maize samples in each moisture range among each market's total tested maize samples

[2] Month of purchase coincides with month in which bids were made

Table 7 presents the same summary statistics as Table 5, but for the 62 traders (16% of the sample) that were exposed to the “aflatoxin information treatment” (AIT). Again, providing maize quality information, in this case about its compliance with the aflatoxin regulation (bags G and H), increased traders’ average bids both in the low and medium moisture ranges; and bids decreased as the moisture content range increased.

Table 7: Summary statistics of traders’ bids by maize bag type in the AIT

	Low Moisture-Unlabeled (A)	Low Moisture-Afla labeled (G)	Medium Moisture-Unlabeled (C)	Medium Moisture-Afla labeled (H)	High Moisture-Unlabeled (E)
Mean (KSh)	2,918	3,098	2,746	2,938	2,287
Std Deviation (KSh)	410	427	442	442	861
Median (KSh)	3,000	3,200	2,900	3,000	2,500
% 0 bid	0%	0%	0%	0%	10%
# Observations	62	62	62	62	124

Low moisture <13.5% (regulation compliant)
Medium moisture 14-15%
High moisture 17-19%

In order to assess the impact of the provision of quality information on traders’ willingness to pay for maize, traders’ bids were regressed on a binary variable indicating whether or not maize quality information (moisture content at different ranges and compliance with the aflatoxin regulation) was provided. The results are shown in Table 8. Linear regressions were run with and without trader fixed effects, and using robust standard errors. The first six columns in Table 8 correspond to the MIT, and each of the three pairs of columns shows the impact of moisture content information on traders’ willingness to pay for maize of a given moisture level (low, medium and high). The results are presented separately for each moisture content range because the impact of precise moisture content information on willingness to pay is expected to differ in sign depending on whether moisture is above or below the regulated level, and also because the value of increasing precision of information on this attribute may differ over its range. The last four columns in Table 8 correspond to the AIT.

Providing information on moisture content has a significant impact on traders' valuation of maize, as long as maize is not extremely wet. Traders were willing to pay around KSh 80 (around USD 0.87) more for maize that was labeled as having moisture content below the regulatory standard, compared to the same quality maize for which no moisture information was provided. This result is significant at a 1% level. The KSh 80 amount represents approximately 13% to 19% of the margin traders earn on a 90KG bag (depending on whether it´s sold wholesale or retail).[30]

Labeling maize as having moisture content just above the regulated level (between 14 and 15%) decreased traders' bids by KSh 68. On the other hand, informing traders of considerably high moisture content in maize (between 17% and 19%) did not seem to significantly influence their willingness to pay, presumably because when maize is very moist traders are able to assess that it exceeds the regulatory standard using rudimentary methods, so more precise information is of little value.

[30] Traders´ average markup per bag was estimated for each market using traders´ asking prices for own maize on sale at the time of the interview, and the prices paid for 90KG bags bought in the last purchases that were made in the same month as the interview. Given that traders in the sample store maize for less than 3 weeks on average, it is reasonable to assume that maize for sale had been purchased recently and hence the prices paid by traders and asking prices in the same month can be used to calculate an estimation of the gross margin per bag. The average markup, estimated in this way, was between KSh 420 and KSh 625 per bag, depending on whether the bag was sold wholesale or retail in 1 or 2KG units. These estimates are in line with the only similar estimate that could be found in the literature: Kirimi et al. (2011) state that maize assemblers' profits are in the range of KSh 130 to KSh 520 per bag.

Table 8: Impact of information on traders' willingness to pay for maize

	Low Moisture		Medim Moisture		High Moisture		Aflatoxin Free - Low Moisture		Aflatoxin Free - Med Moisture	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Information provided through label	79.5***	79.4***	-68.4**	-68.4**	-53.6	-53.6	180.3***	176.7***	190.4***	190.3***
	(15.84)	(15.89)	(24.69)	(24.77)	(51.21)	(51.38)	(17.8)	(18.48)	(23.01)	(23.87)
Education		2.49		13.78		10.12		-18.69		-28.26**
		(15.212)		(8.763)		(22.767)		(13.133)		(11.432)
Experience		4.21		7.71		-1.06		20.37		9.85
		(5.947)		(6.1)		(16.365)		(12.841)		(12.932)
In contact with formal buyers		-107.33		-78.97		300.28		-182.35		-97.29
		(87.372)		(115.99)		(168.711)		(180.954)		(218.21)
Low quality maize is fed to livestock or sold to feed producers		83.25		55.38		488.95***		112.55		180.44*
		(143.594)		(155.211)		(134.384)		(92.237)		(93.054)
Constant	2,896***	2,852***	2,730***	2,558***	1,965***	1,799***	2,926***	2,938***	2,753***	2,908***
	(7.921)	(276.615)	(12.348)	(195.747)	(25.606)	(196.302)	(8.900)	(205.891)	(11.504)	(220.557)
Fixed Effects (traders)	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Observations	610	610	610	610	610	610	122	120	122	120
Number of traders	305		305		305		61		61	
R-squared	0.115	0.016	0.043	0.015	0.011	0.032	0.601	0.13	0.550	0.105

Robust standard errors in parenthesis

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

The control variables included in the specifications without fixed effects relate to traders' background and experiences in the maize business: years of formal education; years of experience in the maize trading business; an indicator variable that captures those who have had contacts with formal buyers (such as NCPB and large millers); and an indicator variable that captures those who report selling their low quality maize to feed producers or feeding it to livestock.[31] The latter variable is the only one that has a significant effect on traders' willingness to pay and only in the high moisture case. Almost a third of the amount traders were willing to pay for the wettest maize is explained by whether they sell such maize to feed producers, who are known for accepting much lower quality maize.

These results suggest that although traders are able to rank maize by moisture content, improving the observability of moisture content could strengthen the link between quality and price. This has the potential to affect upstream maize farming and handling practices and could thus lead to the production of a higher quality crop. This is particularly true given that these traders source mainly from farmers, so affecting traders' incentives could have a direct influence on farmers. Furthermore, it would be reasonable to expect a much larger effect of information on traders selling on a larger scale and targeting buyers that do condition their purchases on passing a moisture content test.

In the case of the AIT, the impact of information on traders´ willingness to pay was even stronger. Traders were willing to pay between KSh 177 and KSh 190 more for the

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[31] Traders classified as having had contacts with formal buyers were those who fulfilled one or more of these conditions: having ever sold to a large miller or NCPB; at least 1 of the 3 largest purchases or sales in the last year involved a moisture meter; at least 1 of the largest 3 sales were made to a large miller or NCPB; reports selling high quality maize to a large miller or NCPB. Using these criteria, 17% of traders were classified as having had or having contact with formal buyers.

bags of maize that were certified as complying with the aflatoxin regulation, compared to identical maize for which no information was provided. These amounts represent approximately 35% of the average margin earned on a 90KG bag. This shows that aflatoxin testing might be more valued by the market than moisture testing. This may reflect the high level of awareness about aflatoxin within this sample (74% of the sample could give a correct definition of what aflatoxin is), and traders' general lack of familiarity with the moisture content regulation (only 16% of traders knew that 13.5% was the maximum moisture content allowed). Also, aflatoxin is harder to assess based on observable characteristics than is maize moisture content, so precise information on moisture content may be less valuable than information about aflatoxin contamination.

The obvious question is why traders are willing to pay substantially more for better quality maize in unobservable attributes if there is no price premium for unobservable characteristics in this setting. There are four potential explanations for this result: switching from the informal to formal markets; own household consumption; the ability to charge a premium for safer maize, if only to particular consumers; and the certainty that the purchased maize has not had water added to fake higher grain weight.

The first hypothesis, that traders aim to sell the higher quality maize to formal buyers, is unlikely in the study setting. Only 12% of the sample had ever sold to NCPB or a large miller, buyers which pay a premium for maize that complies with the regulatory moisture content standard. Further, there is a significant fixed cost of transport to access these markets, so having one bag of maize that complies with the moisture or aflatoxin standard would be unlikely to shift a trader's marketing strategy.

The second possibility is that traders were planning to keep the high quality bags for own household consumption, instead of selling them as part of their business. After submitting their bids, traders were asked what they would do with the two low moisture bags (labeled for moisture and unlabeled) if they won them.[32] In the case of the unlabeled bag (bag A), 5% answered that they would use it for own household consumption. This proportion increased to 9% when traders were asked about maize labeled as complying with the moisture content regulation (bag B). The majority answered that they would sell the bag at the market (87% and 80% for bags A and B, respectively), and the rest said they would either sell them to a school or a miller. In order to check if planning to use the low moisture maize for own household consumption had any influence on the results found, bids were regressed on a binary variable indicating that the trader planned to use either of the two low moisture bags for household consumption. Also, this binary variable was interacted with the low moisture information provision dummy, and the interaction together with its two components were regressed on traders' bids for the low moisture bags. Table 9 shows two specifications: column 1 includes the indicator for planned household use and the interaction with the low moisture information provided, and column 2 includes trader fixed effects (so planned household use drops out and only the interaction term with information on moisture content remains). In the first specification, the planned use of maize for own consumption has a positive and significant effect on bids for the low moisture maize overall, but this effect is not any higher when maize is labeled for moisture content.

[32] The information on planned use of maize if won is only available for the low moisture content bags.

Table 9: Impact of information and planned HH consumption use on bids

	Low Moisture	
	(1)	(2)
Information provided through label	81.3**	81.3***
	(40.862)	(13.437)
Planned household consumption	172.3***	
	(66.188)	
Planned household consumption X Information	-1.6	-1.6
	(97.223)	(42.075)
Constant	2,879***	2,896***
	(29.362)	(6.367)
Fixed Effects (traders)	No	Yes
Observations	600	600
Number of traders		300
R-squared	0.019	0.120

Robust standard errors in parentheses

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

Another possibility is that traders may be able to sell higher quality maize for a premium, at least to some customers. Traders might be able to somehow advertise when their maize is of higher quality and thus charge a premium for it. Or they could sell it to repeat customers, as this may enhance their reputation for selling high quality maize. In the case of aflatoxin-certified maize, the result obtained is striking, as there is no way customers would be able to tell if maize was contaminated or not. It may be that traders, through repeated interactions with customers, have gained their trust and hence may be able to obtain a premium price or reputational advantage by sharing the information with customers that their maize is aflatoxin safe, despite this being an unverifiable claim.

A final possible explanation relates to the fact that water is sometimes deliberately added to maize grains in these markets to increase grain weight (i.e. to profit from selling less grains per bag of a given weight). Therefore, purchasing a 90KG bag of maize grains with certainty that it has a low level of moisture gives traders confidence that they have not been deceived by a reduced quantity of maize grains in a bag of an advertised weight.

3.5 Conclusions

This study was designed with the primary aim of investigating the potential of moisture content testing and labeling as an inexpensive way of encouraging traders to demand drier maize from their suppliers, most of who are farmers. If a price premium based on dryness could pass back to farmers, they would be encouraged to dry and store maize more carefully, or adopt new inputs such as biological-control products, which would contribute to reducing the risk of aflatoxin contamination.

The results show that information on moisture content significantly affects traders' willingness to pay and suggest the observability of moisture content is limited. Also, the effect of information does not appear to be driven by the possibility of selling drier maize to the formal sector, nor by the intention to keep the dryer maize for own household consumption. There appears to be potential for strengthening the price-quality relationship within the informal sector by improving information on moisture content. This could be implemented, for instance, by allowing traders to access moisture meters through agricultural extension services, or through a moisture meter rental scheme that would allow for one device to be used by all traders at each open-air market.

This study also shows that the impact of providing traders with information on aflatoxin contamination is over twice as large as the effect of moisture content information, and therefore could have an even stronger effect on maize handling practices. While there currently exists no market for maize certified as aflatoxin-safe in Kenya, making information on aflatoxin contamination available at various points in the value chain could potentially result in rewarding the traders who supply—and ultimately the farmers who produce—such maize with premium prices, increasing incentives to reduce contamination in the food supply. However, the current price of testing is likely a barrier. Creating a market for certified safe maize would require a comprehensive approach to the problem, as setting up an aflatoxin certification scheme would require not only finding a reasonably costly testing technology, but also establishing a credible public or third-party verification entity.

The results of this study are particularly notable given that credible food labeling is generally not seen in informal markets of the type where the study took place, and where a vast majority of the poorest Kenyans purchase their food.

A limitation of this study, which is shared by similar revealed-preference studies, is that while the incentive compatibility introduced by requiring traders to pay reduces potential bias, one-shot purchase decisions may not be representative of habitual willingness to pay (Hoffmann, 2009). Future studies should address this limitation by analyzing the dynamics of the demand for new products certified for food quality and safety characteristics that are introduced to the market.

Chapter 4: The impact of information on Kenyan consumers' demand for safer food[33]

4.1 Introduction

In most of the developing world, information on the nutritional and safety attributes of food is usually not available. Often, people in developing countries are not even aware of the damage that food they consume can do to their health. In other cases, even though they may be aware, they do not have the option of purchasing food with certainty that its consumption will not damage their health in the short or long run. An important question is whether they would be willing to pay a premium for food that is certified as safe to eat if it was made available to them.[34] Given the low awareness of food safety threats and their health consequences, as well as the liquidity constraints that characterize poor populations, it is worth studying whether demand for safer food exists. What is more, as public health communication has low diffusion in these contexts, it is important to analyze whether the provision of relevant information could influence poor consumers' food purchase decisions.

The purchase of safe food can be thought of as a preventive health or health-seeking behavior because safe food is an input in the production of health. In developing countries, households' investment in preventive health care is low. Among the multiple

[33] This study was partly funded by resources (USD 2,000) from the Luther G. Tweeten Scholarship, awarded to the author by the Agricultural & Applied Economics Association (AAEA) Trust.

[34] It is sometimes argued that food safety should be a pre-competitive criterion, meaning that only safe food should be available for sale (Unnevehr and Hoffmann, 2015). However, in many developing countries that have many of their food value chains plagued with food hazards, going through a phase of food safety certification might be needed in order to create the right incentives for safe food to be grown, processed and marketed.

reasons for this, the most studied in the development economics literature have been liquidity and credit constraints, time-inconsistent preferences, poor supply of preventive care and lack of information (Guyatt et al., 2002; Kremer and Miguel, 2007; Cohen and Dupas, 2010; Dupas, 2011b; Kremer and Glennerster, 2011; Bennear et al., 2013). The focus of this study is on the lack of information.

The human capital model of the demand for health predicts that people will invest in preventive health if its marginal cost is less than the discounted sum of benefits from the lower probability of getting sick (Grossman, 2000). This implies that people should know the relevant health benefits of investing in safer food and be able to form their subjective probabilities of getting sick when a preventive health investment is made and when it's not. In her review of the literature on preventive and curative health investments in developing countries, Dupas (2011b) makes the point that investment in prevention depends on the individual or household's beliefs about the degree to which prevention could reduce the risk of negative shocks, and stresses that the information about health risks available to these decision-makers is therefore important.

Several empirical studies in developing country settings have shown that providing relevant information can have large impacts on preventive health behaviors (Madajewicz et al., 2007; Jalan and Somanathan, 2008; Luoto et al., 2011; Dupas, 2011a; Dammert et al., 2014; Fitzsimons et al., 2014; Bennett et al., 2015). On the other hand, some studies found null or extremely modest impacts of certain types of health information on behavior (Kremer and Miguel, 2007; Dupas, 2009; Luo et al., 2012; Guiteras et al., 2016). There is little agreement in the literature on the best way of framing the information given—what to convey and how to communicate it—in order to encourage positive health behaviors (Bennear et al., 2013).

Even assuming perfect access to information, it is still under debate how to model people's learning process, in which prior beliefs and their updating mechanisms play an important role. Bayesian learning based on Bayesian updating rules is a useful framework to model this process. One of its implications is that the more surprising the information received, the larger the updating effect should be (Lybbert et al., 2007). However, there is some recent evidence in the literature that information processing may not be fully rational and may rely on the use of heurisitics, rather than Bayesian learning (Tversky and Kahneman, 1974; Kremmer and Glennerster, 2011). For example, if attention is a limited resource, there can be costs associated with the processing of information, and therefore more salient information may have a larger impact on behavior (Chetty et al., 2009; Kremer and Glennerster, 2011; Luoto et al., 2011; Spears, 2014).

The goal of this chapter is to explore whether the provision of health risk information can influence consumers' demand for food labeled as safer to eat in a developing country setting. A field experiment to elicit revealed preferences for safer food was conducted in Kenya, where maize, the main staple crop, is highly contaminated with naturally-occurring aflatoxins that are harmful to human health. In Kenya, many people lack complete information about the safety of the maize they consume and the link between aflatoxin-contaminated maize and serious health hazards. Hence, this study aims to characterize consumers' subjective beliefs regarding aflatoxin contamination rates, the level of awareness of aflatoxins' health consequences, and how the provision of information on contamination and health risks can affect demand for safer food. Because maize certified for its aflatoxin content was not available in the market, the experiment included the introduction of an aflatoxin-safe certified maize flour.

As part of this field experiment, maize flour packages on sale at small retail shops were tested for aflatoxin, labeled as safe to eat when they complied with the aflatoxin regulation, and offered for sale for a few days at a 20% premium above untested maize price. Information messages were randomly varied across customers entering the shops who intended to buy maize flour, in order to assess the differential impact of these messages on demand for certified maize. Some customers received information on the consequences of consuming aflatoxin-contaminated food on children's health; a second group received information on its impact on health in general; and two additional groups of customers received information on the prevalence of processed maize flour contamination with aflatoxin in the local area combined with the children's health and general health consequences, respectively. This design allows estimation of the impact that different health messages have, as well as the additional impact of providing prevalence information, which is essential for the formation of subjective probabilities regarding food safety risks faced.

This study has several policy implications. First, one prominent contamination reduction strategy currently being tested in Kenya is the use of biological-control products that, if proved effective and adopted by farmers, could substantially reduce maize contamination with aflatoxin.[35] Therefore, evidence of sufficient willingness to pay

[35] The biological-control technology consists in the development of a natural product that uses the ability of native non-toxic strains of the aflatoxin-producing fungus to outcompete the toxic strains. This technology, widely used in the US, has been shown to reduce the aflatoxin production by over 80% with a single application in the US (Cotty, 2006). This biocontrol method has already been adapted for use in several African countries, including Kenya, and preliminary results of the application of biocontrol products in the fields show that aflatoxin

for the benefits such a technology would provide could incentivize value chain actors (farmers and millers) to adopt or require adoption of the new technology. Second, the impact that different information treatments may have on demand could be an important element for the design of effective communication and marketing strategies aiming to raise awareness and encourage demand for safer food. Finally, a broader contribution of the behavioral response obtained is that this information can be integrated in risk models to help determine the most cost-effective interventions in this area, a practice that is common for many natural resource and environmental problems (Hoffmann, 2010).

4.2 Existing evidence: The impact of information on preventive health behavior

Several studies have explored whether there exists demand for safer and more nutritious food in developing country contexts. Most of these studies have used stated preference methods and have found that consumers are willing to pay a premium for food with these characteristics (Ehmke, 2008; Krishna and Qaim, 2008; De Groote et al., 2011; Ortega et al., 2011). However, as stated preference techniques can suffer from hypothetical bias that tends to inflate WTP (Lusk and Shogren, 2007), some authors believe the existing evidence based on these methods is not strong enough (Birol et al., 2015). On the other hand, a few recent empirical studies using revealed preference methods have shown that consumers in developing countries are willing to pay a

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contamination of maize was reduced between 67% and 99%, depending on the study (Atehnkeng et al., 2008; IITA, 2013; Atehnkeng et al., 2014).

premium for food certified as of higher quality or, specifically, as being safer to eat (Masters and Sanogo, 2002; Ifft et al., 2012; De Groote et al., 2016).

Masters and Sanogo (2002)'s study involved designing a new product—a processed infant food labeled for its nutritional content—in order to assess mothers' WTP for certification in Mali. Using a field experiment that required mothers to make several choices among different infant foods, Masters and Sanogo find that mothers' WTP for certification is around 30% of the price of a can of a well-known branded infant food (about $1.75/kg) or four times the cost of certification. This shows that there exists a high WTP for information about the quality of infant food in this type of setting.

In order to assess consumer valuation of safety labeling, Ifft et al. (2012) inserted a new product in a traditional market and offered discount coupons for either safety-labeled chicken or regular chicken. Ifft et al. find that consumers in Vietnam are willing to pay a 10–15% premium per chicken purchased with a safety labeling that emphasizes safe production, processing, and transport conditions.

De Groote et al. (2016) conducted experimental auctions using the Becker–DeGroot–Maschak (BDM) mechanism to assess Kenyan rural consumers' willingness to pay (WTP) for maize grains tested and labeled for aflatoxin safety.[36] The authors estimate a price premium for the labeled safe grains between 25% and 50%, depending on the area of the country.

The present study shares with these three studies the feature that a new product was introduced in order to assess the value of food safety or quality labels for consumers,

[36] The BDM mechanism consists in having a participant make a bid that is compared to a randomly generated number. If the bid is higher than the random number, the participant buys the good at a price equal to that random number. If the bid is below the random number, he pays nothing and does not get the good. The BDM mechanism is incentive-compatible.

showing that products carrying basic food safety or nutrition information are not readily available in poor countries' markets.

Additionally, some studies have tested whether providing consumers in developing countries with information about the importance of food quality or safety—on top of the information provided through food labels—encourages them to opt for safer or more nutritious food. However, the evidence is thin and inconclusive: while De Groote et al. (2016) find that providing information decreases the impact on WTP for safer food, Naico and Lusk (2010) and Birol et al. (2015) find the opposite result.

De Groote et al. (2016) show that providing rural households with information about aflatoxin's health consequences decreases their WTP for labeled maize. Because of the similarities with the present study, it is worth highlighting the differences between the two studies. De Groote et al. conducted experimental auctions using a BDM process at the household level—hence creating an artificial transaction setting—to assess consumers' WTP for safety-labeled maize grains and the impact of information on their WTP. In contrast, the present study uses a real market setting and real purchases to estimate the influence of information on purchase decisions. What is more, estimating the impact of providing relevant information to consumers is not the main focus of De Groote et al.'s study. The authors test the influence on households' bids of reading a message about what aflatoxin is and its health consequences, whereas the present study tests the influence of providing different types of health consequences and risk prevalence information.[37] Further, De Groote et al.'s study is focused on rural consumers

[37] The message read as part of De Groote et al.'s study explained that aflatoxins are poisonous byproducts of common soil molds that grow on maize plants and grains where they can produce aflatoxins; that consuming large amounts of aflatoxins can cause death; and that chronic low-

and on maize grains, whereas the current study focuses on urban consumers and packaged maize flour, which is usually purchased by urban households that are not the poorest.

Naico and Lusk (2010) conducted a choice experiment in Mozambique to assess consumers' WTP for orange-fleshed sweet potatoes, which are richer in vitamin A relative to traditional white varieties. The study shows that participants who received information about the nutritional value of orange-fleshed sweet potatoes had a higher WTP for this nutritionally-enhanced crop. In line with this finding, Birol et al. (2015) conclude that Indian supermarket customers who received information through flyers that explained the benefits of GlobalGAP certified grapes were significantly more likely to purchase them.

A few of the reviewed studies investigate the influence of prior awareness about food safety risk on consumers demand for safer food, and they find that greater awareness has a positive influence on demand. Using a contingent valuation method, Krishna and Qaim (2008) find that urban Indian consumers who already believed that pesticide residues had a relatively higher risk for human health had a higher WTP for organic vegetables. Ortega et al. (2011) also find—using a choice experiment—that urban Chinese consumers with relatively higher levels of food safety concern had higher WTP for pork certified as safer to eat. Birol et al. (2015) also find a similar result: Indian consumers with higher food safety consciousness prior to the study and who received food safety information had a higher probability of buying safely-produced grapes.

level exposure can lead to liver cancer, immune system disorders, stunted growth in children, and abortion in livestock.

When it comes to the influence of information on preventive health behavior in general (aside from food quality and safety), there are several randomized evaluations that provide evidence that the lack of information might be hindering households' investment in preventive health. Madajewicz et al. (2007) show that providing Bangladeshi households with information of the arsenic concentration in their well water in a binary format—below or above the national safety threshold—increased the probability of their switching to a safe well. Similarly, Jalan and Somanathan (2008) conclude that informing households in an Indian city of the concentration of fecal bacteria in their drinking water increased the use of water-purification techniques.

Several studies have shown that the amount, type and framing of health risk information given affect risk perceptions and behavior. Luoto et al. (2011) study household demand for point-of-use (POU) water treatment technologies in rural Kenya and find that providing information about the contamination status of the community's water sources led to increased preventive behavior (use of POU products), whereas the additional provision of information of the household's own water quality had no further effect. This finding contradicts the idea that more salient messages that give more personalized information should have a bigger impact on health behaviors. The authors also find that using health messages with a contrast framing—highlighting the importance of the preventive behavior in both avoiding disease and improving health—as opposed to a positive framing alone increased POU product adoption rates.

The studies by Dupas (2011a) and Duflo et al. (2011) also show that people respond to certain types of information, while not to others. Both studies conclude that a teacher training campaign in Kenya focused on average HIV/AIDS risk that encouraged abstinence until marriage did not reduce teenage girls' risky behavior. But Dupas (2011a) finds that providing Kenyan teenage girls with information on relative risks of contracting HIV depending on the type of partner had a large impact on the reduction of adolescents' childbearing rate and unsafe cross-generational sex. This shows that it might be more effective to give comprehensive risk information together with prevention messages that provide alternative safer behaviors in order to encourage investment in preventive health.

Dammert et al. (2014) study the effectiveness of mobile phone messages in fostering households' preventive measures against dengue. They find that households that received 30 messages over a period of three months before the peak of the dengue season had a higher probability of taking preventive measures and lower objective measures of dengue risk transmission. The authors compare these positive results with the ones obtained by similar studies that also find positive effects on preventive health behavior after providing health-related information over many months; and they contrast these results with other experimental studies that find smaller effects when information is provided only once, such as in the case of Dupas (2009). Further, the authors find no message framing effects on health behavior, after having tried different sets of text messages that highlighted different aspects of prevention (e.g. monetary framing, gains vs losses framing).

Bennett et al. (2015) show that a microscope demonstration session that allowed individuals in rural Pakistan to see microbes, together with a conventional hygiene instruction session, significantly increased the impact of hygiene information alone. The authors find strong and persistent hygiene and health improvements for participants who were exposed to both sessions and argue that the possibility of corroborating the existence of microbes could be adding credibility (i.e. precision) to the hygiene information received. They also show that the intervention had a smaller impact on those who adhered to traditional medicine, which may indicate prior beliefs in opposition to the germ theory of disease, thus limiting the impact of health risk information.

There is some evidence that very detailed information can be ineffective at promoting preventive health behavior. While Madajewicz et al. (2007) conclude that providing simple binary safe/unsafe information had a positive impact on a preventive health behavior (switching to safe water sources), Bennear et al. (2013) find that, in a similar setting, receiving richer information on the relationship between arsenic exposure and arsenic risk had a negative but insignificant impact on the probability of switching to a safer source of water, i.e., wells with lower levels of arsenic contamination.

On the other hand, some authors find that the provision of information does not promote the adoption of effective preventive health technologies and practices. Kremer and Miguel (2007) find that an intensive health education intervention implemented through schools in Kenya had no effect on children behaviors to prevent infection with intestinal worms (e.g. hand washing, wearing shoes, etc.). Further, Dupas (2009) shows that neither of two message framing options used affected households’ take up of a preventive health product (insecticide-treated bednets) in rural Kenya. Some households received a message that highlighted malaria´s morbidity and mortality, while others received a message that emphasized financial gains from preventing malaria.

The evaluation of a childhood anemia prevention program in rural China supports the primacy of budget constraints (Luo et al., 2012). Educating parents on anemia and its prevention had very little impact on children's anemia status or blood hemoglobin concentration, except when the information was combined with free iron supplements given daily to children at school. Also, Guiteras et al. (2016) show that none of several messaging treatments tested—standard health benefits, disgust message and shame message—had a substantial impact on hand washing, water chlorination or willingness to pay for chlorine or water treatment hardware at the end of a free trial of chlorine dispensers in Bangladeshi slums. The authors infer that budget constraints and convenience are barriers to preventive behavior that cannot be overcome through promotion or education alone.

All these studies that find small or null effects of the provision of health-risk information show that in developing country settings the lack of information might not be the only constraint hindering households' investment in preventive health.

Most of the randomized evaluations cited above have focused on health hazards that have a short run impact on health, such as bacterial water contamination and mosquito-borne infectious diseases (malaria and dengue). The present study deals with aflatoxin contamination, which in general has a much longer-run effect on health, so benefits from preventive behavior can only be seen (if at all) in the long run. In this way, avoiding exposure to aflatoxin is similar to avoiding arsenic in drinking water, preventing anemia in children, and preventing infection with intestinal worms, for which the studies cited above indicate the impact of information on behavior is mixed.

This research also shares with several previous studies the fact that risk prevalence information was provided (Jalan and Somanathan, 2008; Dupas, 2011a; Luoto et al., 2011). All these studies found that such information had a positive influence on the adoption of preventive health practices. Therefore, these two defining characteristics of the experiment conducted in this study—focusing on a long term health hazard and providing risk prevalence information—could create opposing forces on information processing and, ultimately, on behavior change.

4.3 Context

Kenya is among the countries in the world with the highest rates of aflatoxin exposure (Liu and Wu, 2010). Estimates of aflatoxin contamination of maize vary by site and year.Recent studies have found high levels of aflatoxin contamination in maize grains and maize flour in different areas of Kenya. Moser and Hoffmann (2015) found that 26% of around 900 maize flour packages on sale at shops in eight different towns in eastern and central Kenya did not meet the national standard for aflatoxin contamination. A study of maize grains contamination with aflatoxin conducted in 2010 in eastern Kenya—where aflatoxin contamination is most prevalent—found that 39% of 1500 samples had aflatoxin levels above the maximum legal limit (Mutiga et al., 2014). The maize samples were collected from people who brought their maize for grinding at small local mills. The contamination rate varied from 22% to 60%, depending on the district, showing the high variability across the country. Another study, conducted in a different part of the country that is less affected by aflatoxin (western Kenya), found that 15% of milled maize samples also collected from small mills' clients had aflatoxin contamination levels above the regulatory limit (Mutiga et al., 2015).

More than a decade ago, a survey conducted in 2004—after an aflatoxicosis outbreak—in 65 markets located in eastern Kenya found that 55% of the sample of 350 maize products tested had aflatoxin levels above the regulatory limit (20 ppb at that time), 35% had levels above 100 ppb, and 7% had levels above 1,000 ppb (Lewis et al., 2005).

Chronic aflatoxin exposure is linked to three human health problems: liver cancer, child stunting and immune system suppression. The most studied and documented disease linked to chronic aflatoxin exposure is liver cancer (Strosnider et al., 2006). There is vast evidence of the significant role of aflatoxin in the worldwide liver cancer burden. Liu and Wu (2010) show that between 5% and 28% of all liver cancer cases can be linked to aflatoxin-contaminated food and 40% of these cases are concentrated in Africa. Using a different methodology, Liu et al. (2012) obtained a similar estimate: 23% of liver cancer cases annually around the world can be attributable to aflatoxins. Additionally, aflatoxin has also been linked to impaired growth in children (Gong et al., 2002, 2003 and 2004; Khlangwiset et al., 2011) and immune system disorders (Turner et al., 2003; Jiang et al., 2005; Jiang et al., 2008).

Even though there are a few studies that report consumer awareness levels about the presence of aflatoxin in Kenyan maize, very little is known about the awareness of the specific health risks associated with aflatoxin. A survey of 1500 maize consumers from a sample of 112 villages across Kenya's high-aflatoxin-prevalence Eastern region shows that only half of the consumers had heard of aflatoxin and 42% believed it was harmful to human health (Hoffmann et al., 2013). This study shows that when asked to compare homegrown maize with maize purchased from traders, only 20% of consumers believed that their own maize could make them sick, compared to 93% in the case of purchased maize. Further, De Groote et al.'s (2016) study conducted in rural Kenya in 2010-2011—two years before the present study—estimated that 64% of 1342 surveyed households had heard about aflatoxin, but only 16% knew that aflatoxins can cause health problems. These numbers show that there exists some level of awareness of the linkage between contaminated maize consumption and health problems, but the specific health problems perceived to be associated with aflatoxin have not been explored.

The maximum aflatoxin content allowed in maize by Kenyan regulatory standards is 10 parts per billion (ppb). However, this regulation is not enforced in the informal markets and weakly enforced in the formal market, where only part of the maize that is purchased and converted into flour by large millers is tested for aflatoxin and rejected when found to be contaminated. Kirimi et al. (2011) state that corruption exists at large millers, particularly at the level of gate security and quality testing. Hence, when facing a maize purchase, consumers cannot tell if it is contaminated with aflatoxin, not even when they purchase maize flour packages at shops and supermarkets (Moser and Hoffmann, 2015).

4.4 Project and Data

Over three months in 2013, customers were interviewed and subjected to randomly-assigned information treatments prior to entering small retail shops in four urban or peri-urban towns in the Eastern and Nairobi provinces, Kenya. The same customers were also interviewed on their way out of the shops to record their maize purchase decisions. Participants were not told that they would be interviewed a second time until they had completed shopping. The sample consists of 349 customers recruited at the four study sites (Table 1). Two of these shops (in Machakos and Nairobi) are small supermarkets (mini-markets); one is a small convenience shop, locally called *duka* (in

Chuka); and the last one is a medium-sized supermarket (in Nairobi).[38] The period of time spent surveying customers at each shop ranged between three days and slightly more than two weeks.

Table 1: Vendors' location, type and number of customers interviewed

Vendor	Location	Province	Type	Month visited	# Days visited	# Customers
1	Machakos	Eastern	Small supermarket	Jul-13	9	78
2	Nairobi	Nairobi	Small supermarket	Aug-13	15	124
3	Chuka	Eastern	Duka	Sep-13	17	121
4	Nairobi	Nairobi	Medium supermarket	Sep-13	3	26
					44	349

Before conducting the surveys, maize flour packages from the most popular brands at each shop were tested for aflatoxin using rapid aflatoxin test strips, which are easy to use in the field and produce quick results.[39] Those packages of flour that complied with the aflatoxin regulation (aflatoxin content below 10 ppb) had labels affixed that said that the flour was aflatoxin tested and compliant with the regulation, and were placed on the shelves, together with the regular untested packages. Approximately one quarter (23%) of the tested maize flour was contaminated and thrown away.[40] On average, seven different

[38] The difference between a duka and a mini-market is that the former has the merchandise on sale behind the owner's counter, so it's the owner who grabs the goods that customers decide to buy. At mini-markets customers can walk through the aisles and grab goods by themselves.
[39] The rapid aflatoxin tests used (Agrastrip™) are produced by Romer Labs and are an FDA/GIPSA approved method for testing maize.
[40] The contamination rate (23%) was obtained from a sample of 346 tested flour packages that were purchased at the 4 stores where the experiment was conducted. 78 of these packages tested above 10 ppb for aflatoxin.

brands were tested and labeled per shop. The labeled packages were priced with a 20% premium above the price of the corresponding brand of untested maize flour.[41]

Before entering the shops, customers were asked if they were planning to buy maize flour and if they gave a positive answer, a brief explanation of the study was given to them and those who agreed to participate were interviewed.[42] The questions asked were related to awareness about aflatoxin contamination and maize flour quality more broadly. After answering the questions, customers were told that a new product had been introduced at the shop that day, which consisted of packaged maize flour tested for the contaminant aflatoxin. It was emphasized to customers that the regular non-tested version was still available, so they could buy either the tested maize flour or the regular non-tested flour.

After this, customers were randomly assigned to different information treatments. Approximately one quarter of the sample was read a message that highlighted the long-run health risks to children of consuming aflatoxin-contaminated food. The message, to which I refer as the "child health message", read:

> *"Scientific studies have shown that children who are fed frequently with food that is contaminated with aflatoxin, such as maize flour, may be more vulnerable to disease, and may not grow as well as other children".*

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[41] This price premium was chosen based on a pilot study using a similar method to test demand for certified maize at various price points. The pilot showed that 53% of consumers purchased tested flour offered at a 20% price premium. Purchase rates at lower price levels were close to 100%, raising the concern that variation in purchase behavior at price premiums below 20% would be too low to detect the impact of messages.

[42] The enumerator described himself to customers as part of a team of researchers from a university that were conducting a "study on maize" and explained that the survey was anonymous.

Another quarter of the sample was read a script that stressed the general long-run health consequences of consuming aflatoxin-contaminated food. This "general health message" read:

> *"Scientific studies have shown that frequently eating aflatoxin-contaminated food, such as maize flour, may cause people to develop liver cancer and also make them more vulnerable to disease in general".*

Another quarter of the sample was read the child health message and a "contamination message" with information about the local prevalence of aflatoxin contamination. Because it was essential to communicate the risk level in a way that was easily understood by customers whose literacy level could be relatively low, special thought was given to the way in which contamination rates would be explained. The contamination message read:

> *"Maize contamination with aflatoxin in certain Kenyan regions is quite common. Last month, we performed some tests on maize flour of different brands at several shops like this one in this area. We found that 25% of the tested maize flour for sale is contaminated with aflatoxin. This means that every four times that you buy maize flour, one time you'll get contaminated maize flour".*[43]

[43] The 25% contamination rate was estimated as part of a larger study on demand for certified maize that took place during the three months previous to the beginning of this study. The estimated contamination rate was obtained from a sample of 555 tested flour packages that were purchased at seven different shops located in towns in the Eastern and Nairobi provinces. The seven shops had high contamination rates, being the lowest rate 17% and the highest, 40%.

The last quarter of the sample received both the general health message and the contamination message. Table 2 summarizes the distribution of customers across information treatments.

Table 2: Customers' assignment to information treatments

	Assignment to treatments		Bought maize	
	#	%	#	%
Child health information	95	27%	90	95%
Child health + contamination information	90	26%	88	98%
General health information	83	24%	76	92%
Gral health + contamination information	81	23%	73	90%
Total	349	100%	327	94%

The enumerator stayed outside the shop while customers made their purchases, so customers would not feel observed. When customers came out of the shops, they were approached again by the enumerator, who conducted the exit survey. The exit questionnaire aimed to find out if they had ended up buying maize, what type of maize had been bought and the reasons for the choice made, and to obtain some basic socio-economic characteristics from them. Further, in order to confirm what type of flour had been purchased, the enumerator asked customers to show him the maize bag(s) purchased.

The fraction of customers in each treatment group that bought maize after entering the shops is shown in Table 2. On average, 94% of customers who said they were planning to buy maize when entering the shop ended up buying maize, which shows that the targeting of maize flour customers was good. Customers' decision whether to end up buying maize or not—independent of the maize type chosen—could have been influenced by the information treatment received. Table 2 shows that the decision to buy maize is slightly unbalanced: those who received the child health message ended up buying maize in a higher proportion than those who did not receive it (and this is significant at the 10% level). Therefore, the main outcome variable (whether to buy the certified option or not) is defined below for all customers who said they were planning to buy maize—independent of whether they actually bought or not—coding those who ended up not buying maize as if they had chosen the regular non-tested flour.

4.5 Descriptive Statistics

Table 3 shows average socio-economic characteristics of the surveyed customers. Customers were primarily female (63%) and had relatively high levels of education: 96% had completed primary school, 66% had completed secondary school and 20% had completed post-secondary studies. Customers were on average in their early thirties and 58% of them lived in households with children under the age of 10. The fact that, in an urban/peri-urban area, 57% of customers' households grew maize shows how common it is for Kenyans to grow maize on their own plots to feed their families. Using principal component analysis, a wealth score was created that encompasses the household's ownership of several assets: television, refrigerator, house, car/truck, electricity and gas for cooking.

Table 3: Average socio-economic characteristics in the sample, by treatment group and tests of difference in means between treatment groups

	# Obs	Mean	Mean by Message (1)				P-values of differences (2)	
			Child	Not Child	Contam	Not Contam	Child vs. Not	Contam vs. Not
Female (%)	349	63%	60%	67%	63%	63%	0.189	0.978
Age (# years)	309	33	33	34	32	35	0.247	0.024**
There are children in HH (%)	328	58%	63%	53%	60%	57%	0.099*	0.421
Completed primary school (%)	349	96%	97%	94%	96%	96%	0.103	0.919
Completed secondary school (%)	349	66%	68%	64%	67%	65%	0.364	0.609
Completed post secondary school (%)	349	20%	17%	23%	19%	21%	0.261	0.601
HH grows maize (%)	349	57%	60%	54%	59%	56%	0.476	0.936
Wealth score	349	-0.03	-0.03	-0.03	-0.04	-0.01	0.163	0.492
Knowledge score	349	0.02	0.15	-0.13	0.14	-0.10	0.096*	0.162
Nonzero contamination prior (%)	349	23%	26%	20%	26%	20%	0.136	0.152
n		349	185	164	171	178		

(1) Note that the child health message and the contamination information treatments were cross-cut. Thus, the union of the Child and Not Child groups constitute the whole sample, as do the union of the Contam and Not Contam groups.

(2) P-values are from separate linear regressions of each variable on the two message treatment indicators (child and contam) and vendor dummies.

*** p<0.01, ** p<0.05, * p<0.1

In order to assess balance across message treatments, mean consumer characteristics by group were calculated, and the p-values of the tests of difference in means between these were estimated for each characteristic (Table 3). The only significant difference across treatments at 5% level of significance is age: those customers who received the contamination message were younger than those who did not receive it. Nonetheless, the magnitude of the average difference is relatively small (two and a half years of age), so a priori it should not be a concern. Also, the proportion of customers with children in their households is significantly higher among those who received the child health message, but only at the 10% significance level.

As part of the entry survey, and before receiving any information treatment, customers responded a series of questions that aimed to assess their baseline knowledge about aflatoxin's effect on human health and the extent to which they incorrectly believed the toxin is observable. Customers' prior knowledge could have an impact on purchase decisions independent of the information messages received. Table 4 presents means of the responses to these questions. It shows that 57% of the surveyed customers not only had already heard about aflatoxin but also knew that aflatoxin could make people sick. This relatively high level of awareness about the fact that aflatoxin is harmful for human health could be due to the fact that the sample was mostly urban and with relatively high education levels. De Groote et al. (2016) estimated that only 16% of the rural households surveyed as part of their study in Kenya knew that aflatoxins can cause health problems.

In terms of ability to assess maize contamination, only around a third of the surveyed customers in the current study knew that aflatoxin cannot be detected by sight, and only one quarter of the sample knew that contaminated maize can still taste fine.

Even fewer customers (21%) knew that it is possible that aflatoxin-contaminated flour does not make people sick when they consume it (i.e. aflatoxin consumption can have a chronic unnoticeable effect on human health). These answers show that even though urban Kenyans might have a broad idea about aflatoxin and it being harmful for humans, when it comes to more detailed information, the level of knowledge is low. With the answers to these four questions, a knowledge index was constructed using principal component analysis, to be used in the econometric analysis. Table 3 shows the mean value of the knowledge score and that it is higher among those who received the child health message (only at the 10% level of significance).

Table 4: Previous knowledge about aflatoxin

	Mean
Know aflatoxin is harmful for human health	57%
Know aflatoxin contaminated flour can look fine	37%
Know aflatoxin contaminated flour can taste fine	25%
Know flour can be aflatoxin contaminated but not make one sick	21%
# Observations	349

Given that only one statistical difference was found at the 5% level of significance—that represents a 5% of total possibilities—the balance across message treatments is good. Still, in order to control for any slight differences across treatment groups and to improve precision of the estimated treatment effects, the analysis presented below includes specifications in which the variables shown in Table 3 are included as controls.

In order to find out how much customers knew about the specific health risks caused by aflatoxin exposure, before receiving any information customers were asked what they believed were the main two risks associated with aflatoxin contamination.[44] More than a quarter of the sample knew that aflatoxin can cause immediate sickness (dizziness, vomiting, etc.). However, the proportions of customers who knew that aflatoxin can cause death (14%), cancer (8%) and problems to children's health (3%) were extremely low, confirming the low level of awareness about the specific risks that aflatoxin poses to human health.

Table 5: Awareness about aflatoxin's specific health risks

	Mean
Believe aflatoxin can cause death	14%
Believe aflatoxin can cause cancer or long term health problems	8%
Believe aflatoxin is bad for children	3%
# Observations	349

Before receiving any of the information messages, customers were asked if they believed maize flour for sale at a shop like the one they were about to enter could be contaminated with aflatoxin. 23% of customers gave a positive answer, i.e., around a quarter of the sample had nonzero contamination priors (Table 3). This shows that there's widespread unawareness about the high prevalence of aflatoxin contamination. After this,

[44] The survey questions did not ask for all possible health risks associated with aflatoxin, but about the main risk, followed by a second question asking about other possible risk. Therefore, the 23% of the customers that gave answers to both questions could have mentioned more than two risks if the question had been formulated differently. This wouldn't have significantly changed the conclusions obtained from the data (i.e., awareness would still be low), but to avoid a possible bias in these answers it was decided not to use them in the econometric specifications below.

customers were asked, out of 10 times that they bought maize flour at a shop like the one they were visiting that day, how many times they might purchase maize flour that was contaminated with aflatoxin. Around 40% of customers interviewed did not know the answer, mostly because they did not know what aflatoxin is. Around 40% of the customers who gave an answer believed that it was not possible to get contaminated flour at a local shop. What is more, 95% of those who gave an answer to this question had a subjective contamination probability that was below the 25% contamination rate estimated for this study and included in the contamination message. Table 6 presents the distribution of answers given by customers. The average subjective probability of flour contamination with aflatoxin is around 0.3%, well below the 25% maize flour contamination rate calculated for this study.[45] These results reinforce that there is a large underestimation of the prevalence of aflatoxin in maize flour packages for sale among the studied population.

[45] This subjective contamination prevalence was calculated assuming that those customers who did not know the answer to the probability question—the majority of which did not know what aflatoxin is—had a 0% contamination prior. The argument is that people who have not heard about aflatoxin cannot believe there's a positive probability of purchasing contaminated maize. Even leaving these customers out and calculating the subjective contamination prevalence only with those customers that either gave a zero or positive answer, the subjective contamination rate would reach 0.55%, still less than a percentage point and far below the 25% contamination rate estimated for this study.

Table 6: Customers' subjective probabilities of maize contamination with aflatoxin

# Contaminated bags (out of 10)	Subjective contamination probability	# Customers	% Customers
0	0%	142	41%
1	10%	45	13%
2	20%	10	3%
3	30%	6	2%
4	40%	2	1%
5	50%	2	1%
Does not know		142	41%
Total		**349**	**100%**

4.6 Results

4.6.1 Impact of the information messages

The fact that 40% of the surveyed customers bought tested flour suggests a high demand level given that they had to pay a 20% price premium over regular untested flour. Table 7 shows the share of customers who bought the tested flour in each of the information treatments. The highest proportion of customers who bought tested flour (46%) is among those who received the contamination message, and the lowest proportion (38%) is among those who received the general health message.

Table 7: Proportion of customers who bought tested, by message group

	# Obs	Mean (%)	Message received					
			Contamination		Child health		General health	
			#	%	#	%	#	%
Bought tested flour	140	40%	78	46%	77	42%	63	38%
Bought regular flour	209	60%	93	54%	108	58%	101	62%
Total	349		171		185		164	

Table 8 presents the most commonly mentioned reasons behind customers' purchase decisions. Around three quarters of those who bought tested flour said they did so for safety reasons in general or concern about aflatoxin in particular. Other reasons for purchasing the tested flour were curiosity (14%) and believing it might taste better (7%). Half of the customers who decided instead to purchase the regular unlabeled maize flour indicated that this was because the price for tested flour was too high. The other main reasons for not buying the tested flour were trust in the regular brand (18%), having been sent to the shop with specific purchase instructions (9%) and not knowing what aflatoxin is (5%).

Table 8: Reasons for buying tested and untested flour

	# Obs	Mean (%)
Bought tested flour[1]	140	43%
Reason: worried about aflatoxin/safety	107	76%
Reason: curiosity/comparison	20	14%
Reason: taste	10	7%
Bought regular flour[2]	187	57%
Reason: price too high	97	52%
Reason: trusts regular brand	34	18%
Reason: sent to buy with specific instructions	17	9%
Reason: does not know what aflatoxin is	10	5%

[1] Other reason for buying certified: trust in test.

[2] Other reasons for buying regular: mistrust in test; not having enough money.

The dichotomous dependent variable Y_{ij} is the decision of customer i at vendor j whether to buy the certified maize flour or not ($Y_{ij}=1$ if certified flour is bought). Y_{ij} is a function of two indicator variables that reflect the treatment messages received, the child health message (CH) and the contamination message (CO). Y_{ij} is also explained by a vector of consumer and consumer's household characteristics X_{ij}, vendor fixed effects V_j and unobservable variables included in a spherical random disturbance u_{ij}. The base estimated regression is given by:

$$Y_{ij} = \alpha + \beta_1 CO_{ij} + \beta_2 CH_{ij} + \boldsymbol{\delta X_{ij}} + \boldsymbol{\theta} \sum_{j=1}^{3} V_j + u_{ij}$$

Those customers that ended up not buying maize were coded as if they had chosen the regular non-tested flour ($Y_{ij} = 0$), because they would eventually buy this type of maize, not the tested flour that could only be purchased that day at that specific shop. Omitting those customers who decided not to buy maize could lead to biased estimates of the messages' impact through selection bias.

Linear probability models (LPMs) were estimated in order to assess the impact of the different information treatments on customers' purchase behavior. Because LPMs violate the assumption of homoskedastic error terms, robust standard errors were used in all specifications. The choice of a LPM over a logit or probit model is based mainly on the fact that although logit and probit models are specifically designed to handle binary dependent variables, these procedures handle fixed effects poorly (Angrist and Pischke, 2008). Also, the coefficients estimated by LPMs are already marginal effects and do not require any transformation as in the case of logit or probit estimations.

Aside from the binary independent variables indicating the experimental treatments, interaction terms were included in some specifications to allow for possible non-additive effects. The variables included in the specifications with controls are: female (binary), age, three binary variables to show the level(s) of education completed (primary school, secondary school and post-secondary studies), whether the household grows maize (binary), whether there are children below 10 years old in the household (binary), the wealth score and the aflatoxin knowledge score. Also, all the specifications include vendor fixed effects, since assignment to treatment was stratified at the vendor level.

Column 1 in Table 9 presents the simplest specification. The contamination message has a positive and significant effect on the decision to buy tested flour: it increases the probability of purchase by 10 percentage points relative to those who did not receive the contamination message. On the other hand, the child health message does not have a significant impact above the general health message. Receiving the contamination and child health messages together increases the expected probability of buying the labeled flour by 12 percentage points above the impact of the general health message alone ($p<0.1$), conditional on having the same values for the controls.

Column 2 presents the same regression as column 1, but it includes control variables. The contamination message still has a positive and significant effect (10 percentage points, $p<0.05$), almost identical to the one obtained without controls. When analyzing the sign and significance of the control variables, several interesting results emerge. Women do not seem to be more inclined than men to buy the certified option, nor does growing maize at home or having children in the household influence the decision. However, older customers have a significantly higher propensity to buy certified, with each additional year of age increasing the probability of buying tested flour by 0.6 percentage points. This was a surprising result that could guide the targeting of future communication campaigns that try to raise awareness about this problem.

Also, having a higher level of education significantly increases the probability of buying certified: having completed secondary and post-secondary school increases 9.6 percentage points ($p<0.1$) and 21 percentage points ($p<0.05$), respectively, the chance of opting for the labeled flour. Further, wealthier customers have a 4 percentage point higher chance of buying certified, as shown by the positive and significant coefficient of the wealth index created. Customers who already knew before the experiment that aflatoxin is harmful for human health and how it can be assessed in maize, have a 7 percentage point higher probability of buying certified flour. This could be due to prior knowledge increasing trust in the information received.

Table 9: Impact of the different information treatments on buying certified flour (OLS)

	Bought certified flour	
	(1)	(2)
Contamination message received	0.1036**	0.0996**
	(0.048)	(0.046)
Child health message received	0.0190	0.0139
	(0.049)	(0.046)
Female		0.0693
		(0.046)
Age		0.0061**
		(0.003)
Completed primary school		0.1014
		(0.123)
Completed secondary school		0.0966*
		(0.057)
Completed post-secondary school		0.2136***
		(0.065)
HH grows maize		-0.0825
		(0.052)
Children below 10 in the household		0.0354
		(0.051)
Wealth score		0.0407**
		(0.021)
Aflatoxin knowledge score		0.0753***
		(0.016)
Constant	0.6826***	0.2785
	(0.063)	(0.189)
Vendor fixed effects	Yes	Yes
Observations	349	328
R-squared	0.170	0.333

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.6.2 Influence of having children in the household

The hypothesis tested here is that customers who live in households with children might find the child health message more relevant and hence it might have a stronger effect on their decision to buy the labeled alternative than on customers who do not live with children in their households. On the other hand, receiving the contamination message should not have a differential effect on customers who have children in their households.

Table 10 shows the differential impact of the information treatments on those households that do and do not include children below 10 years old. Balance across treatment groups among households with and without children was checked through tests of difference in means for all the relevant baseline variables, and is presented in the appendix (Table A.1). Among households that included children, the proportion of female customers is 16 percentage points lower in the group that received the child health message (5% significance level). If women were more likely to invest in child health as some authors have shown (Duflo, 2003; Qian, 2008), we would expect that having fewer female customers in the child message group would only bias downward the estimated child message effect.

Column 1 shows that without controls, customers whose households include children were not differentially affected by the child health message compared to those whose households do not include children. Receiving the contamination message has again a positive and significant estimated coefficient, and similar in value to the previously estimated ones. When controls are added to this specification (column 2), the differential effect of receiving the child health message on customers whose households have children becomes significant (p<0.05) and is above 18 percentage points. Column 3 includes both messages (child health and contamination) interacted with customers having children in the household, but excludes control variables. In this case, none of the interaction effects are significant. Specification 4 includes both interactions, as well as the control variables. The additional effect of the child health message on customers who live with children is again significant and close to 18 percentage points. There is not sufficient statistical power to reject a null impact of the contamination message separately for those with and without children, though the value of the coefficient on this treatment remains similar to that estimated in models without the interaction, which itself has a coefficient close to zero (0.0257). Hence, these results present some evidence that the child health information provided had a differential impact on those who live with children in their households.

Table 10: Differential impact of the information treatments on HHs with children (OLS)

	Bought certified flour			
	(1)	(2)	(3)	(4)
Contamination message received	0.1129**	0.1006**	0.0840	0.0856
	(0.051)	(0.045)	(0.080)	(0.070)
Child health message received	-0.0638	-0.0937	-0.0636	-0.0937
	(0.079)	(0.070)	(0.079)	(0.071)
Child health message X children in the HH	0.1549	0.1861**	0.1557	0.1867**
	(0.103)	(0.094)	(0.103)	(0.094)
Contamination message X children in the HH			0.0497	0.0257
			(0.105)	(0.092)
Children below 10 in the HH	-0.0440	-0.0628	-0.0684	-0.0755
	(0.078)	(0.073)	(0.093)	(0.090)
Constant	0.6754***	0.3209*	0.6877***	0.3286*
	(0.085)	(0.189)	(0.088)	(0.194)
Controls	Not included	Included	Not included	Included
Vendor fixed effects	Yes	Yes	Yes	Yes
Observations	328	328	328	328
R-squared	0.149	0.341	0.150	0.342

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.6.3 Influence of prior beliefs of aflatoxin contamination prevalence

Consumers' prior beliefs about the prevalence of aflatoxin contamination could also influence the impact of the contamination message on their purchase decisions. As was explained above, customers' subjective probability of contamination was elicited, in 10 percent increments. This is used to test the influence of prior beliefs about aflatoxin contamination risk on the impact of receiving new information about the local contamination prevalence.

Following Lybbert et al. (2007) and Birol et al. (2015), a Bayesian learning process based on Bayes rule, could be summarized in the following equations:

$$\pi_{i|c} = \delta_i \pi_i + (1 - \delta_i)\pi_c = \pi_c + \delta_i(\pi_i - \pi_c)$$

where $\pi_{i|c}$ is consumer i's updated subjective probability of maize flour contamination after receiving the contamination message c; π_i is consumer i's contamination prior before receiving any information; π_c is new information received by customers, i.e., the 25% contamination prevalence that was informed to some of the customers in the sample; δ_i is a measure of consumer i's confidence in his prior contamination belief; and $(1 - \delta_i)$ indicates consumer i's confidence in the contamination message received.

Therefore, Bayesian updating rules anticipate that new contamination prevalence information would have a greater updating effect when: i) the customer has lower confidence in his prior beliefs (larger variance of the prior beliefs distribution); ii) the customer has greater confidence in the contamination message received; and iii) the contamination information received is more surprising relative to the individual's prior beliefs. The last proposition implies that learning that the local contamination prevalence is 25% should have a smaller impact on customers whose prior estimate of the contamination rate was similar to this level, relative to those whose prior estimate was further from this level. Having a contamination prior larger than 25% means that the contamination message received would have updated downward the contamination prior, and hence led the consumer to a lower updated contamination prevalence. A lower updated risk prevalence is not expected to have a positive impact on the decision to buy a safer bag of maize flour (if anything, this change should decrease demand for safety-labeled flour). In contrast, having a contamination prior lower than 25% means that the contamination message would have led to a higher updated contamination prevalence; and the larger this updating effect—the further away the prior belief from the informed 25%—the larger the effect on the probability of buying certified maize.

To test this learning model, three indicator variables were constructed to reflect the probability range of customers' prior contamination beliefs: those with zero contamination priors, those with 10% and 20% contamination priors (i.e., below 25%), and those with contamination priors above 30%. Balance was checked for the baseline variables across those who received the contamination message in each of these groups vs the respective comparison groups (see Table A1 in the Appendix). There are several significant differences at 1% and 5% levels in the group with priors above 30%, due to the small number of observations in this group (10 customers had priors above 30%, 8 of which received the contamination message, and 2 did not). Sample characteristics are balanced within the other prior belief categories.

Column 1 in Table 11 shows that receiving the contamination message increases the probability of buying certified maize by 38 percentage points ($p<0.01$) among individuals with 10% and 20% contamination priors (i.e., who believe there is a positive chance that local shops sell contaminated maize flour but below the informed contamination prevalence). Further, customers who had contamination priors above the informed contamination rate (i.e., priors equal or above 30%), were also positively and significantly affected by the contamination message: their probability of buying certified maize is 47 percentage points above those with similar priors who did not receive the contamination message ($p<0.05$).[46] On the other hand, the contamination message had no significant effect on those with zero priors (the omitted category among the priors variables in the regression).

Specification 2 in Table 11 shows essentially the same result. Those customers who thought it was impossible for a local store to sell aflatoxin-contaminated maize, when faced with the new information that the local contamination prevalence was 25%, did not have a higher probability of buying certified flour. A test of joint significance of the effect of the contamination message on those with zero priors shows that the effect is not significant and close to zero.

These results are at odds with the Bayesian updating model, under which the contamination message would be expected to have the largest (positive) impact on those with the lowest subjective prior beliefs of contamination probability. Instead, the contamination message had a larger effect on those who were less surprised by the new information because they already had relatively high risk perceptions (both those who

[46] An F test was conducted to test the equality of effects for those with priors of 10-20% and those with priors above 30%, and the equality of effects could not be rejected.

had to revise downwards their priors and those who had to revise them upwards but starting from a nonzero prior). Customers who had a zero contamination prior should have been the most affected by the new information, but they were not.

Table 11: Influence of prior beliefs on contamination prevalence (OLS)

	Bought certified flour	
	(1)	(2)
Contamination message received	0.0277	0.4054***
	(0.049)	(0.111)
Child health message received	0.0145	0.0177
	(0.046)	(0.045)
Contamination prior = 10% and 20%	-0.1656	
	(0.102)	
Contamination message X Prior = 10% and 20%	0.3550***	
	(0.132)	
Contamination prior >=30%	-0.1066	
	(0.142)	
Contamination message X Prior >=30%	0.4466**	
	(0.205)	
Contamination prior = 0%		0.1614*
		(0.096)
Contamination message X Prior = 0%		-0.3772***
		(0.122)
Constant	0.2855	0.1185
	(0.191)	(0.201)
Controls	Included	Included
Vendor fixed effects	Yes	Yes
Observations	328	328
R-squared	0.357	0.356

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

One interpretation of these results is that people may be able to give a meaningful answer about whether they believe there is any chance that maize in local shops could be contaminated with aflatoxin, but less able to give a meaningful estimate of the precise probability of contamination (since contamination is generally unobservable). For those who believe there is some chance of contamination (regardless of the specific subjective probability they state), receiving information that 25% of flour is contaminated above the regulatory limit leads them to believe that the risk is sufficiently high to warrant purchase of labeled flour. On the other hand, those who believe there is zero chance of contamination (half of whom had never heard of aflatoxin) may ignore the new information about the risk because such information is not credible given their priors that aflatoxin is not a threat.

This interpretation is consistent with the original formulation of Bayes rule:

$$\boldsymbol{Prob}\ (\boldsymbol{A}|\boldsymbol{I}) = \frac{\boldsymbol{Prob}(\boldsymbol{I}|\boldsymbol{A})\boldsymbol{Prob}(\boldsymbol{A})}{\boldsymbol{Prob}(\boldsymbol{I})}$$

if we define its elements as follows:

Prob(A|I) = updated subjective probability that maize is contaminated, given that the new information is correct.

Prob(I|A) = subjective probability that new information is correct, given prior subjective belief regarding possibility of contamination

Prob(A) = prior subjective belief that maize may be contaminated

Prob(I) = subjective belief that the new information is correct

For those with zero priors of aflatoxin contamination, Prob(A) is zero, and hence the updated subjective probability of contamination is also zero (Prob(A|I)=0). In other words, there is no learning. For those with a positive prior of aflatoxin contamination

(Prob(A)>0), Prob(I|A) is positive. Holding Prob(I) constant, this results in higher updated subjective probability of contamination for those with a non-zero prior relative to those with a zero prior.

It should be noted that those customers with positive priors were more likely to be aware that aflatoxin exposure is harmful for human health. In fact, all participants with positive priors were aware that aflatoxin causes health problems, compared to only 46% of participants with zero priors. Although all participants were given information on the health impacts of aflatoxin exposure (either through the general health or child health messages), this information may have been less credible to those with no prior knowledge that aflatoxin is harmful for humans. It was not possible to separate the influence of both contamination priors and health risk priors due to the lack of any intersection between those with positive priors of contamination probability and those unaware of the health risks associated with aflatoxin exposure.

A model of limited attention (a rational model with information processing costs) is also consistent with these results. Under such a model, receiving information about the rate of contamination could change behavior by adding salience to an already known problem, regardless of whether or how this information updates beliefs. It is also possible that information that is closer to prior beliefs has a lower processing cost and hence a larger impact on behavior.

It should be kept in mind that there could be some endogeneity in the contamination prior variables biasing the estimated coefficients. This could be the case if there were unobservable factors correlated with, for instance, wealth or education and the contamination priors. Having higher education levels or higher wealth could be correlated with being better informed and having better comprehension skills and hence having higher contamination priors. In such case, the results obtained could be due to a better comprehension of the information given, and not to the message itself. These factors, together with the fact that the sample of customers who had positive contamination priors is very small, imply that these results have to be interpreted with caution and should be explored further.

4.7 Conclusions

This work shows that information alone can induce people to make an investment in order to decrease a health risk, even if the investment is costly. Almost half of the customers who participated in this study decided to purchase aflatoxin tested maize at a 20% price premium. Further, the type of information provided does seem to influence behavior. Information on the local prevalence of aflatoxin contamination, which exceeded the vast majority of customers' contamination priors, had the strongest impact on demand. This information increased the probability of customers buying the labeled flour by between 9 and 11 percentage points. This study demonstrates that combining information on the prevalence of a risk with the health consequences of such risk appears to be the most effective approach for changing preventive health behavior.

The results presented differ from those reported by De Groote et al. (2016), which show that the WTP for tested labeled maize of participants who received information was 7% lower and that the WTP of participants who knew that aflatoxins are toxic was 8% lower. The authors argue that both information received and prior knowledge did not increase the WTP for tested maize—and even reduced WTP for the regular untested maize—probably due to a negative impact on the valuation of maize in general of raising awareness about a potential contaminant. My results, in contrast, indicate that both information and prior knowledge positively influence the decision to purchase certified flour. In particular, previous knowledge about aflatoxin increased the probability of buying the labeled alternative by around 7 percentage points. This is important because it shows that education campaigns—which are a relatively inexpensive policy tool—are likely to be effective not only for raising awareness about the risks of aflatoxin exposure, but also have the potential to increase demand for safer food. Further, the results imply that concentrating such efforts in those areas where current awareness is low could help motivate the adoption of preventive health behaviors.

Existing evidence points to the severely harmful effect that aflatoxin has on children's health, in particular through exposure to contaminated food early in life, which is associated with stunted growth. This in turn has negative consequences for the development process in poor countries. Therefore, it was of particular interest to assess the impact of the provision of information on child health risks related to aflatoxin exposure. The study shows that receiving information on child health consequences of exposure had an effect that was 18 percentage points larger for customers whose households include children, relative to those who don't. This result shows that public health communication strategies might be more effective when they are able to provide information that is more relevant for the targeted population.

Similar to Ifft et al. (2012) and Birol et al. (2015), this study finds that more educated consumers have higher willingness to pay for safe food. Customers that had completed post-secondary studies had a 20% higher probability of buying the certified flour. Further, women in the sample were not more likely to buy the safer flour option, in coincidence with some studies that have not found gender differences in willingness to invest in preventive health (Dupas, 2009). Not surprisingly given the large size of the price premium, wealthier customers had a higher chance of choosing the certified maize. Birol et al. (2015) list several studies that have estimated consumer demand for food safety in developed countries, and state that in general these studies have found that demand for safer and higher quality food increases with income, education and food safety awareness levels. These results coincide with what was found in this study in a very different setting.

This study also finds that a prior belief that contamination is not possible could limit the impact of providing risk information. Having positive priors about the contamination prevalence increased the effect of the provision of risk prevalence information on purchase behavior. A possible explanation is that information that has lower processing costs or that is more credible given prior beliefs has a larger impact on customers' purchase decisions. Similar to Ortega et al. (2011)'s suggestion that higher subjective risk perceptions could encourage higher willingness to pay for food safety information, these beliefs may be associated with greater readiness to process and act on information on the rate of contamination, as the possible disutility from not choosing the safer option could be higher for those already aware and concerned about the food safety problem.

Most of the literature on the constraints to preventive health investment in developing countries has found that information, in particular when it is provided only once, has very small effects on demand (Dammert et al., 2014; Dupas, 2009). The high demand level observed for certified flour in this study as well as the large impact of information are quite surprising, in particular when compared with the low take-up of other preventive health inputs in similar settings and with much smaller price premiums. This could be due to the fact that food safety, which is by definition bundled with food itself, has specific characteristics that distinguish it from other preventive health products. For example, choosing a safety-labeled package of food instead of a regular untested one does not require any additional effort and cooking one or the other is an identical activity. In contrast, purchasing and using an insecticide-treated bed net or a water-purification technology require large changes to routine activities and additional effort and time. Also, food safety can sometimes be—or be perceived as—correlated with taste, a food attribute that is very much valued and can only be assessed after purchase. For instance, in this study, 36% of customers who knew what aflatoxin is had the incorrect belief that contaminated flour must taste poorly. However, only 7% of customers who bought the certified maize said they did so because they believed it might taste better, so it does not seem to be an important reason to explain the purchase behavior observed.

Some caveats of the results presented in this study should be noted. Perhaps most importantly, consumers received health and prevalence information immediately prior to making a purchase decision. The salience of this information was thus at its peak, leading to maximum impact. It is likely that the impact of this information on purchase decisions would fade over time. On a related note, as has been noted in the literature, one time purchases can differ from recurrent purchase behavior, especially when a large price premium is involved. Future studies should analyze the behavior of demand over longer periods of time. In the case of maize flour that is aflatoxin tested, this would require making a reliable and consistent supply of tested maize packages available.

Second, the fact that consumers were not sure if they would be able to purchase safer certified maize again in the future could have made them choose the regular option because a sole purchase of safe maize would have an extremely marginal effect on their health. Further, given that the label did not have a governmental or other well-known identification, customers could have not trusted the label. On the other hand, the same fact that consumers did not know if they would be able to purchase the certified option again could have made them curious to try something that might not be available in the future. In this latter case, the decision to purchase certified would not be driven by health reasons, but rather by curiosity to try something new. As noted by Ifft et al. (2012), any field experiment conducted in a single period of time that aims to test the willingness to pay for a new product is subject to the influence of both curiosity and skepticism for the unknown product.

4.8 Appendix

Table A.1: P-values of tests of difference in means by message assignment, relative to comparison group

	Influence of having children in the HH on the effect of the child health message (1)		Influence of subjective contamination priors on the effect of the contamination message (2)		
	Child Message (vs Gral) HHs with children	Child Message (vs Gral) HHs without children	Contam Message Received (vs Not) Zero contam priors	Contam Message Received (vs Not) 10%-20% contam priors	Contam Message Received (vs Not) >=30% contam priors
Female (%)	0.02**	0.33	0.93	0.49	0.31
Age (# years)	0.85	0.46	0.10	0.03**	0.03**
There are children in HH (%)	-	-	0.30	0.73	0.96
Completed primary school (%)	0.44	0.21	0.73	0.91	0.29
Completed secondary school (%)	0.83	0.27	0.91	0.79	0.00***
Completed post secondary school (%)	0.87	0.08*	0.18	0.83	0.007***
HH grows maize (%)	0.55	0.94	0.52	0.42	0.00***
Wealth score	0.37	0.26	0.71	0.46	0.28
Knowledge score	0.63	0.13	0.48	0.89	0.30
n	111	66	134	29	8

The comparison group is shown between brackets in each column title. Given the experiment design, the comparison group for the child health message is the general health message, irrespective of receiving the contamination message. The comparison group for the contamination message is not receiving this message, irrespective of receiving either the child health or general health messages.

(1) P-values are from separate linear regressions of each variable on the child message interacted with having children in the HH, the contamination message and vendor dummies.

(2) P-values are from separate linear regressions of each variable on the contamination message interacted with the different ranges of priors, the child message and vendor dummies.

*** p<0.01, ** p<0.05, * p<0.1

Chapter 5: Conclusions

The goal of this dissertation was to analyze the response of food value chain actors when faced with otherwise unobservable food safety and quality information in real market settings in a developing country. Given that food safety comprises several unobservable or imperfectly observable characteristics, the absence of testing technologies, certification schemes and information labels in these settings leads to uninformed choices that can have negative health consequences for consumers. The two field experiments conducted in Kenya tested if traders and customers' informed choices reflect willingness to pay a premium for safer and higher quality food, and if the provision of different types of information could have a differential impact on their demand for this type of food.

The results show that traders and consumers in this context were willing to purchase food labeled as safer and higher-quality for a premium, confirming that the observability of moisture content and aflatoxin contamination is limited. Information on both maize moisture content and aflatoxin contamination significantly affected traders' willingness to pay, with the impact of aflatoxin contamination labeling being over twice as large. A possible explanation suggested for this—although one impossible to either prove or refute given the available data—is that traders might be able to sell this safer maize to customers with whom they have built trust through repeated transactions. When it comes to consumers, almost half of the customers in the experiment were willing to buy certified maize flour at a 20% price premium over regular untested flour, demonstrating that on average there is a high level of concern about aflatoxin-contaminated maize.

Further, the consumers experiment provided evidence that lack of information constrains investment in safer food, which can be considered a preventive health behavior. It also showed that the impact of health messaging on purchase of tested maize varies significantly depending both on the specific content of the message, and on the characteristics and prior beliefs of consumers. This coincides with several studies in the economics literature that have found that information can have large impacts on preventive health behaviors and that the type and framing of information matter. Information on the local prevalence of aflatoxin contamination, which exceeded the vast majority of customers' contamination priors, had the strongest impact on demand. Similar to what studies have found in developed country settings, demand for safer maize increased with income, education and food safety awareness. What is more, having non-zero priors about the probability of contamination increased the effect of the provision of prevalence information on purchase behavior, contradicting a learning model that predicts that more unexpected information should have larger updating effects. Finally, the results showed that information that is more relevant for the targeted population, specifically the impact on child health for customers whose households include children, may be more successful at achieving the expected change in preventive health behavior.

Increasing the observability of food safety and quality in the context studied is not an easy task. Improving information on moisture content in informal maize markets is probably the most feasible mechanism to strengthen the price-quality relationship within these markets given that moisture testing technology is inexpensive and it could reach traders through agricultural extension services or through a moisture meter rental scheme. However, testing and labeling for aflatoxin at informal markets do not seem viable mainly due to the current high cost of testing, in particular given the small scale that characterize transactions in these markets. In the case of processed maize flour, making aflatoxin-tested and certified flour available for consumers in Kenya could be implemented given that most of the maize flour is processed by a small number of large millers. Still, creating a reliable and consistent supply of certified safe maize flour would require a comprehensive approach to the problem, including establishment of a credible public or third-party verification entity, providing access to technologies that help reduce contamination at all stages of the value chain, and reducing the number of transactions from farm to table.

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