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by
Andrew M. Johnson,
Joan R. Fulton, Nicole J. Olynk Widmar
Dept. of Agricultural Economics, Purdue University
West Lafayette, Indiana 47907-2056
johns993@purdue.edu, fultonj@purdue.edu, nolynk@purdue.edu

Tahirou Abdoulaye, Bamikole Ayedun, Adebowale Akande,
Ranajit Bandyopadhyay and Victor Manyong
International Institute of Tropical Agriculture
PMB 5320, Oyo Road, Idi-Oshe
Ibadan, Nigeria.
t.abdoulaye@cgiar.org

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Abstract

Aflatoxin is a potent mycotoxin that can cause cancer, stunted growth, and (in extreme instances) rapid death. Aflatoxin can contaminate many staple crops, including maize and groundnuts. As many as 4.5 billion people in the developing world may be chronically exposed. Scientists at the United States Department of Agriculture – Agricultural Resource Service, International Institute of Tropical Agriculture (IITA), and African Agricultural Technology Foundation have developed a biological control product called Aflasafe. IITA is currently working with the AgResults initiative to promote widespread adoption of Aflasafe in Nigeria and with the Aflasafe Technology Transfer and Commercialization Program to promote Aflasafe adoption in 11 African countries. In the fall of 2016, 272 oral surveys were administered to maize-buying poultry producers and feed millers in Nigeria. The survey was developed to obtain data regarding farmer awareness of aflatoxin and Aflasafe. Levels of aflatoxin and Aflasafe awareness were higher among enterprises registered with state and federal government agencies than among enterprises not registered. Awareness levels were also higher among enterprises with membership in professional poultry associations. The percentage of enterprises within each state that controlled for aflatoxin in their maize supply, typically with the use of toxic binder, ranged from 2% to 92%. Only 4% of enterprises tested for the amount of aflatoxin in their maize supply.

Keywords: aflatoxin; Aflasafe; AgResults; maize millers; poultry farmers; Nigeria

JEL Codes: D29; I15; O13

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Funding for this research was provided by the United States government's Feed the Future Initiative. This research was conducted by Purdue and IITA through the CGIAR program on Agriculture for Nutrition and Health (A4NH) led by IFPRI. Dr. Muhammad Baba Bello of Bayero University assisted with survey design and enumerator training. Dr. Elizabeth Byrd of West Virginia University assisted with survey design. Mr. Onu Anyebe, Funke Akomlafe, and Ogundapo Ademola of the International Institute of Tropical Agriculture (IITA) helped coordinate enumerator training and data collection. Thanks also to all the enumerators who were part of this study. Also the authors recognize the ADP for helping to compile the list of poultry producers and feed millers, which allowed us to start the sampling procedure. The efforts of Mr. Deji Degun and Akinsitan Akinwale of Oyo State; Mr. Dayo Mejabi and Olusola Adegboyega Ojo of Kwara State; Mr. Nuhu Lawal Tunkunyagwari (Hakimin Kidandan) of Kaduna State; Mr. Abass Shehu of Bauchi State; Mr. Mairafi Sabo of Nasarawa State; and Mr. Ejeba Joseph of Benue State are also recognized. The authors are finally extremely appreciative of all the poultry producers and feed millers in Bauchi, Benue, Kaduna, Kwara, Nasarawa and Oyo States who voluntarily responded to the questionnaires for this research.

Introduction

Aspergillus flavus, a fungus commonly found in soils and on grain and legume crops, produces "aflatoxin", a highly carcinogenic mycotoxin (Williams et al., 2004). The Centers for Disease Control and Prevention (2012) claim that about 4.5 billion people in the developing world are chronically exposed to dangerous levels of aflatoxins through their diet. Countries situated between the 40ºN and 40ºS latitude with "hot, humid, draught-prone climates" are most at risk (Narayan, 2014, p.2).

Chronic aflatoxin ingestion has been shown to cause liver disease and, in high concentrations, death in both humans and domestic animals (Williams et al., 2004). Aflatoxin is strongly linked to immune-system suppression, increased susceptibility to diseases, and growth retardation, notably stunting (Gong et al., 2002; Turner et al., 2003; Williams et al., 2004). Recent research suggests an association between consumption of aflatoxin contaminated maize ("corn" in the US) and the susceptibility to, and progression and severity of HIV/AIDS and opportunistic infections (Obuseh et al., 2011). Hepatitis B infection is believed to substantially increase the risk of liver cancer resulting from aflatoxin consumption (Groopman, Kensler, & Wild, 2008). Aflatoxin consumption also reduces the growth rate and productivity of farm animals (Williams et al., 2004).

There are two crops, maize and groundnuts ("peanuts" in US), that are particularly susceptible to aflatoxin contamination (Liu & Wu, 2010). These crops are significant sources of human food and animal feed in sub-Saharan Africa. Aflatoxin contaminated maize or groundnuts represent a significant risk to human health and a threat to trade in domestic and international markets (Otsuki, Wilson, & Sewadeh, 2001). Furthermore, toxic residues have been found in dairy, meat, and poultry products of animals fed aflatoxin-contaminated feed (Iqbal et al., 2014; Keyl & Booth, 1971).

The International Institute of Tropical Agriculture (IITA), in partnership with the United States Department of Agriculture–Agriculture Research Service (USDA–ARS), the African Agricultural Technology Foundation (AATF) and national partners in Africa have developed a biological control technology to control aflatoxin. The product is named Aflasafe.

Aflasafe (www.aflassafe.com) is a safe product composed of natural strains of Aspergillus flavus that do not produce toxins (Bandyopadhyay et al., 2016). When Aflasafe is introduced in a farm field, the non-toxic strains outcompete the strains that produce the toxins, through a process known as competitive exclusion (Atehnkeng et al., 2008). Aflasafe is currently the most effective technology for aflatoxin mitigation in maize and groundnut at the pre-harvest stages (Bandyopadhyay et al, 2016). The protection continues even when the grains are in storage (Bandyopadhyay et al, 2016).

The core biocontrol technology was developed by the United States Department of Agriculture–Agricultural Research Service (USDA–ARS). IITA has taken the lead in adapting and improving the technology for Africa and is spearheading its adoption under the name Aflasafe. It is currently in use in Nigeria, Kenya, and Senegal.

The product is registered as Aflasafe^{TM} in Nigeria. Efforts are being made to scale out the technology in Nigeria through the AgResults Nigeria Aflasafe pilot project. The goals for that pilot project are to improve consumer health outcomes, generate economic benefits for smallholder farmers, and build a sustainable market for Aflasafe^{TM} (AgResults Initiative, 2015). A group of "implementer" companies are enrolled in the pilot project to provide Aflasafe to farmers and aggregate the resulting production of "aflatoxin-safe" maize (i.e. maize with a sufficiently low aflatoxin concentration to be safe for human consumption). Pilot project staff conduct tests to verify the levels of aflatoxin and Aflasafe in the maize those farmers produce. If the prevalence of Aflasafe is sufficiently high, a premium of US$18.75 (₦3,000) per metric ton is paid (AgResults Initiative, 2017). In the typical range of maize prices, this represents a premium of 5-13%, the anticipated long-term premium for aflatoxin-safe maize (AgResults Initiative, 2017). During Year 1 of the pilot project in the 2014 growing season, around 3,200 farmers worked with the nine implementers enrolled in the program (AgResults Initiative, 2017). Of the maize plots treated with Aflasafe in Year 1, 97% tested for less than 2 parts per billion (ppb), a level below both the US standard of 10 ppb and the EU standard of 4 ppb (AgResults Initiative, 2017).

IITA is in the process of developing and registering unique Aflasafe products in other African countries. In 2016, IITA – with funding from the Bill and Melinda Gates Foundation and United States Agency for International Development – launched the Aflasafe Technology Transfer and Commercialization (ATTC) Program. ATTC is a five year project to promote Aflasafe registration and adoption in eleven African countries: Nigeria, Kenya, Senegal, The Gambia, Zambia, Burkina Faso, Ghana, Mozambique, Tanzania, Malawi, and Uganda (Partnership, n.d. b).

Two fundamental questions need to be answered: What are the economic incentives for farmers to adopt the new technology? Are the economic incentives similar for human food, animal feed, and export markets? To address these question, economists from IITA and Purdue University are working together on a project known as ChoiceAflasafe. ChoiceAflasafe is funded by a grant from the United States government's Feed the Future Initiative.

ChoiceAflasafe is intended to analyze users' acceptance of Aflasafe in Nigeria. The study targets two types of uses of aflatoxin-safe maize: human food and animal feed in the poultry industry. The target audience for human food use is smallholder farmers, and the target audience for poultry feed use is agribusiness enterprises (i.e. enterprises that produce poultry, feed, or a combination of poultry and feed). Separate surveys were developed and administered to each group. For both groups, survey respondents completed a discrete choice experiment and answered demographic questions and questions about their understanding of aflatoxin.

This paper presents the preliminary results from the agribusiness survey. Information about poultry producer and feed miller demographics, aflatoxin awareness, aflatoxin control practices, and Aflasafe awareness are presented below.

Data and Methodology

Primary data was collected for this study. IITA and Purdue personnel collaborated to develop a survey using the latest methodology for choice experiments. To ensure full coordination, Purdue staff made two visits to IITA operations in Nigeria. Dr. Joan Fulton visited in May 2016 to help initiate survey development. Dr. Fulton and Andrew Johnson visited again in September 2016.

They were centrally involved in the roll out of the survey interviews. Working with IITA staff the team developing and delivering training to the enumerators who were conducting the surveys. Enumerators were trained from September 28-29, 2016, at IITA's station in Abuja, Nigeria. Fulton and Johnson also participated with IITA staff in the initial testing in a village by the enumerators in a village. IITA staff recruited a team of 15 enumerators. Every enumerator holds a bachelor's degree, and some have more advanced degrees. Enumerators were trained from September 28-29, 2016, at IITA's station in Abuja, Nigeria.

There were 3 classes of agribusiness enterprises: those from Benue and Kwara States (states where there is awareness of Aflasafe but Aflasafe is not used); those Kaduna and Oyo States (states with Aflasafe users), and those from Nasarawa and Bauchi States (states where there is generally not awareness of Aflasafe). Fifty poultry farmers and feed millers (50) were expected to be drawn from each state, to make a total of 300 agribusinesses. Specifically, Farmer Association of Nigeria provided ChoiceAflasafe with a list of agribusinesses in each appropriate control group. A list from Farmer Association of Nigeria could not be obtained in Nasarawa State; hence, a list of available poultry farmers there was provided by Nasarawa State Agricultural Development Program (ADP). The IITA staff carrying out the survey randomly selected 50 agribusiness enterprises in every state. In Bauchi and Nasarawa states, many poultry farms were no longer operating due to a shortage of maize grains and certain other factors. Consequently, 50 agribusiness enterprises could not be obtain from each of these states. In summary, the following numbers were obtained from each state: 51 in Oyo State and 47 in Kaduna State (states with Aflasafe users), 50 in Kwara State and 51 in Benue State (states where there is awareness of Aflasafe but Aflasafe is not used), and 28 in Bauchi State with 45 in Nasarawa State (states where there is generally not awareness of Aflasafe). The number of valid agribusiness enterprise observations from all the states was 272.

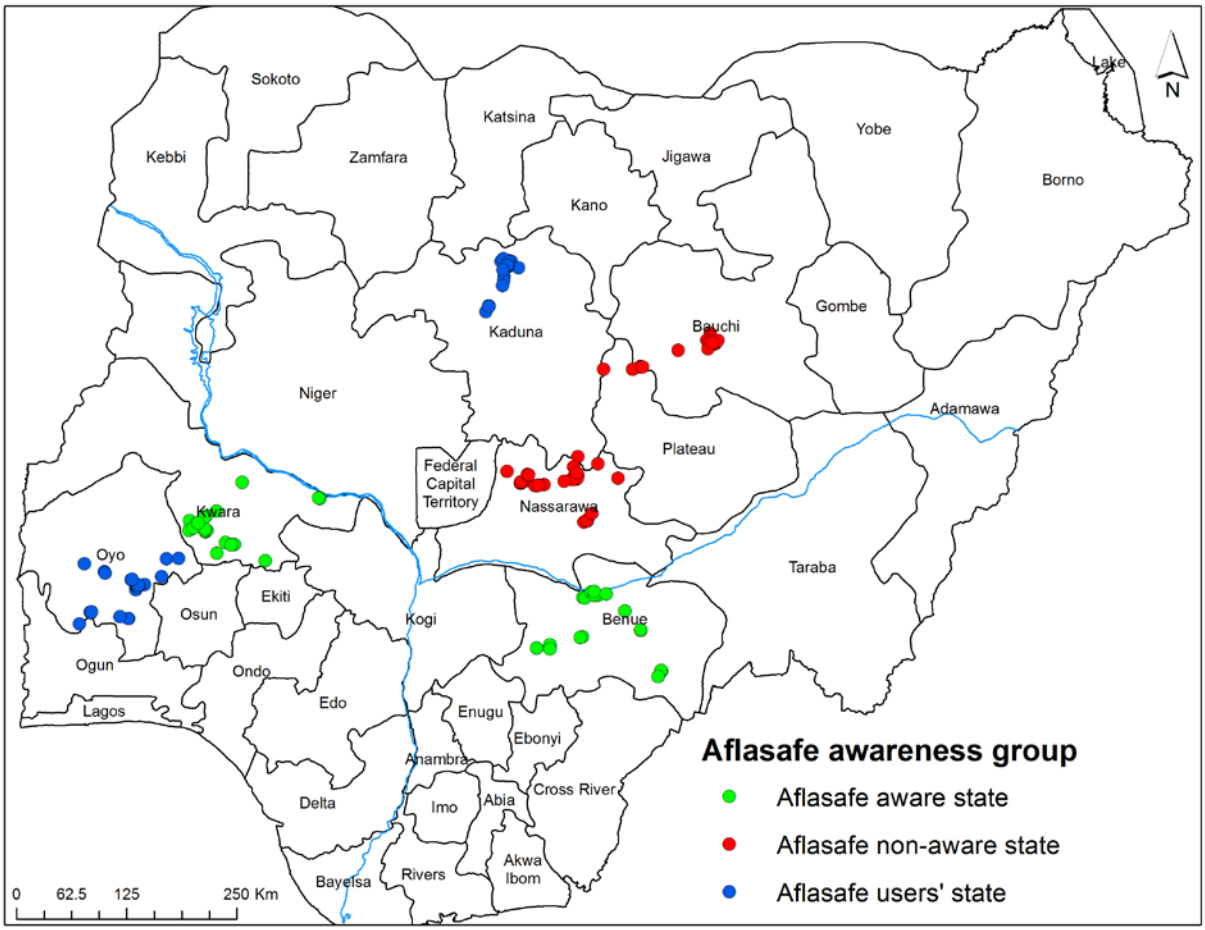
The survey received Internal Review Board approval from Purdue University and IITA (IRB Protocol #1606017881). Enumerators explained to respondents that participation was voluntary. Enumerators received verbal consent before proceeding with surveys. Responses to questions were recorded in CSPro 6.3. After conducting the discrete choice experiment, respondents were asked 21 questions about the characteristics of their enterprises. The agribusiness survey, excluding the choice experiment, is provided in the Appendix.

Results and Discussion

General Agribusiness Enterprise Characteristics

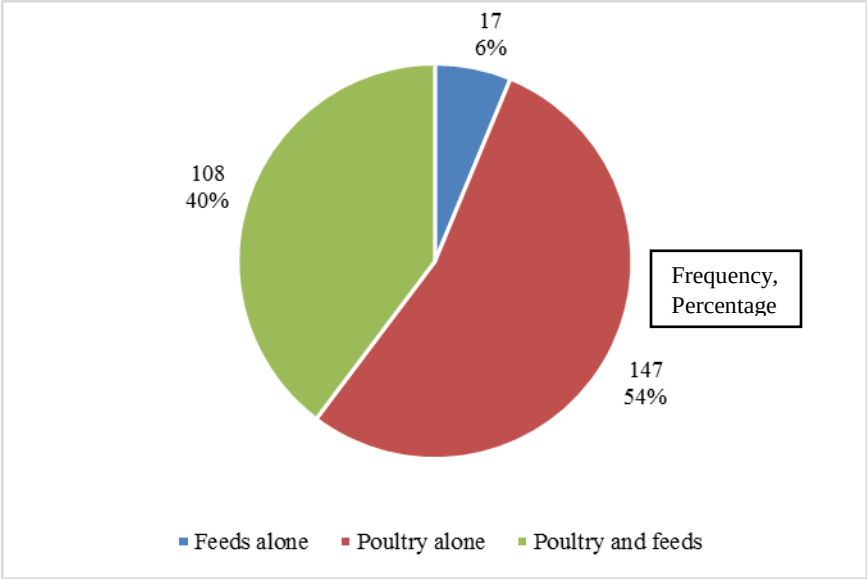
The precise locations of agribusiness surveys are shown by the blue dots in Figure 1. The numbers of enterprises sampled from each state are displayed in Figure 2. The numbers in Figure 2 reflect the fact that a small number of observations were removed from Nasarawa, Kaduna, Benue, and Bauchi States because those enterprises do not make use of maize grain. Approximately equal numbers of enterprises were sampled from Oyo (n=51), Nasarawa (n=45), Kwara (N=50), Kaduna (N=47), and Benue (N=51) States. The number of observations was smallest in Bauchi State (N=28), where many poultry enterprises had closed due to a scarcity of maize grain.

Figure 1. Location of Agribusiness Surveys



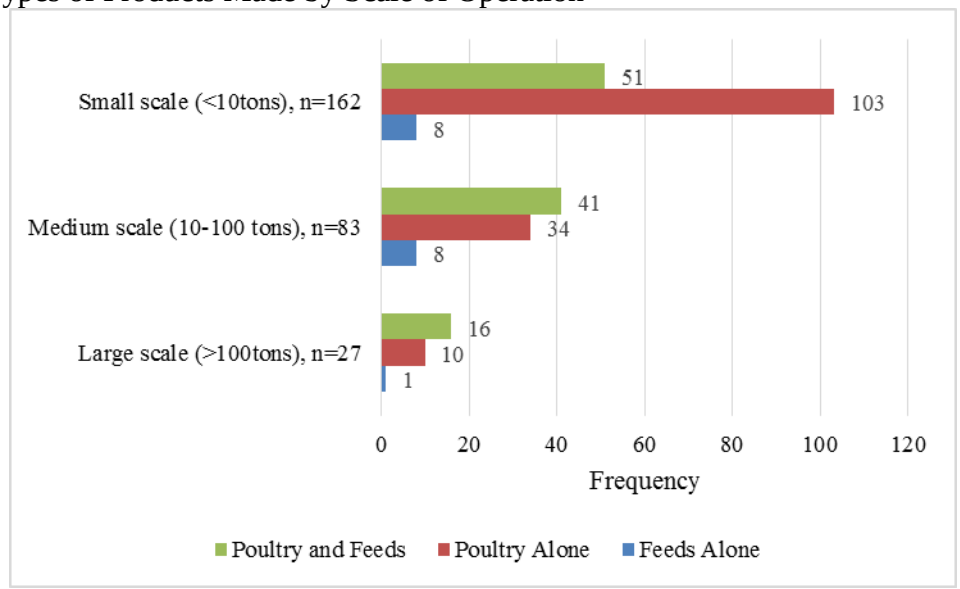
Agribusiness enterprise respondents were asked what kind of products they make. As seen in Figure 2, 147 enterprises produced only poultry and 108 produced both poultry and feed. Only 6% of the sample group produced only feeds. None of the survey respondents indicated that their enterprise milled food products for human consumption.

Figure 2. Products Made, n=272



The distribution of products made, based on scale of enterprise, is shown in Figure 3. Scale classifications were based on the volume of maize used per annum. Small scale operations used less than 10 tons of maize per year and constitute 60% of the agribusinesses. Medium scale operations used between 10 and 100 tons per year and represent 31% of the agribusinesses. Large scale operations used over 100 tons of maize per year and make up 10% of the agribusinesses. Seventy percent of small scale enterprises produced only poultry, as illustrated by the uppermost red bar in Figure 3.

Figure 3. Types of Products Made by Scale of Operation



In addition to questions about production and scale, respondents were also asked a series of questions about the demographic characteristics of the head of the enterprise and about the

attributes of the business. Results of binary questions are reported in Table 1 and the results of open-ended questions are reported in Table 2.

Table 1. Summary of Binary Demographic Variables, n=272

	Count	Percentage of Sample
Enterprises with a Female Head	44	16.2%
Enterprises that are Sole Proprietorships	239	81.8%
Enterprises with Access to Microcredit	69	25.4%
Enterprises Registered with NAFDAC	22	8.1%
Enterprises Registered with Local or State Government	166	61.0%
Enterprises Belonging to a Professional Poultry Association	145	53.3%
Enterprises Belonging to a Professional Milling Association	45	16.5%
Enterprises that are an Implemeneter with AgResults	21	7.7%
Enterprises that Work with an AgResults Implementer	4	1.5%

Sixteen percent of the enterprises had a female head. The average age of the head of each enterprise was 45.1 years. The average age of the head was 1.1 years higher than the median age. The average enterprise head had 15.8 years of formal education, and only two enterprises had a head without any formal education.

Table 2. Summary Statistics of Continuous Variables, n=272

	mean	median	sd	min	max
Age of Head of Enterprise	45.1	44.0	11.7	23	90
Number of Years of Education of Head of Enterprise	15.8	16.0	2.5	0	21
Years Enterprise Has Been in Operation	8.9	7.0	7.7	1	50

The average number of years that an enterprise had been in business was nine (Table 2). The median number of years in operation was 7. Because the mean was larger than the median, the distribution of years in operation was skewed right. Approximately one-quarter of enterprises had access to microcredit (Table 1). Eighty-eight percent of the enterprises were sole proprietorships (n=239). Other ownership structures indicated by respondents included: private limited companies (n=20), partnerships (n=5), cooperatives (n=3), public companies (n=3), joint public/private ownership (n=1) and other (n=1).

Enterprises were registered with local or state governments at a much higher rate (61.0%) than with the National Agency for Food and Drug Administration and Control (NAFDAC) (8.1%). Similarly, enterprises were members of professional poultry associations or bodies at a higher rate (53.3%) than they were of professional milling associations or bodies (16.5%).

Twenty-one enterprises (7.7% of sample) were implementers with the AgResults Nigeria Aflasafe pilot project. Sixteen of these twenty-one enterprises were located in Oyo, Kwara, or Kaduna States, the three states in this sample where the pilot project was most active as of October of 2015 (AgResults Initiative, 2015). Only four enterprises report doing business with an implementer with the pilot project. Interestingly, three of the four were located in Bauchi State. There were no implementers with the pilot project in Bauchi State as of October 2015, but Bauchi State boarders Kaduna State, where there were active implementers during that time (AgResults Initiative, 2015).

Access to Microcredit

The proportions of men and women with access to microcredit are illustrated in Figure 5. As demonstrated by the blue bars, women in this sample had access to microcredit at a substantially lower rate than men, 15.9% compared to 27.2%. The proportion of enterprises with access to microcredit varied widely by state, as can be seen in Figure 6. The only two states where the rates of access were above the sample mean of 25.4% were the southwestern states of Oyo and Kwara. Benue and Kaduna States had rates of access to microcredit that are around the sample mean. The rates of access are below 10% in Bauchi and Nasarawa States.

Figure 5. Access to Microcredit by Gender

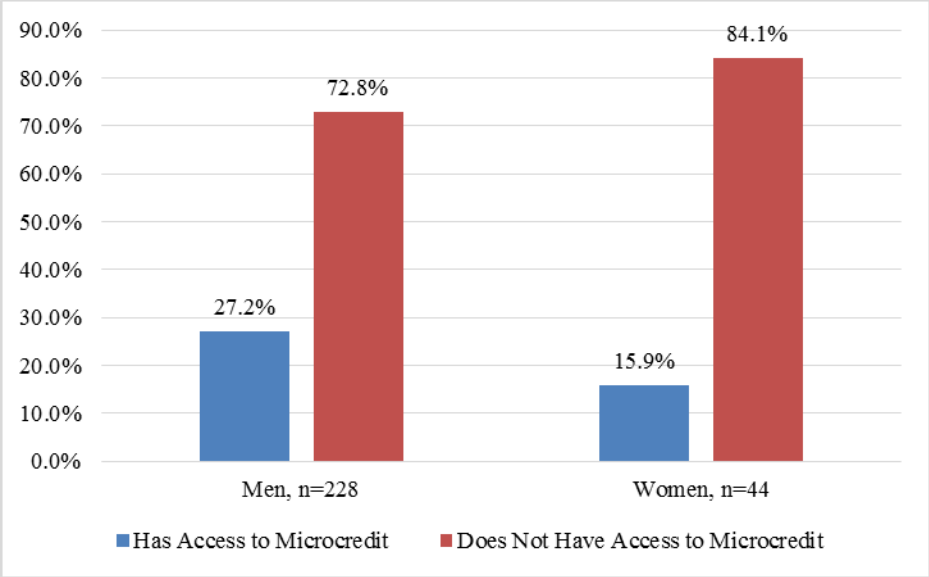
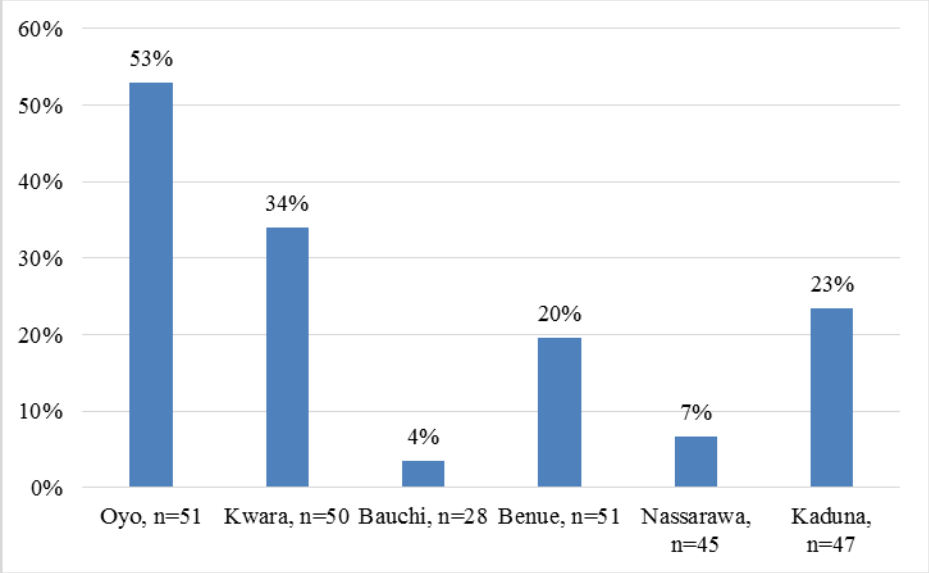
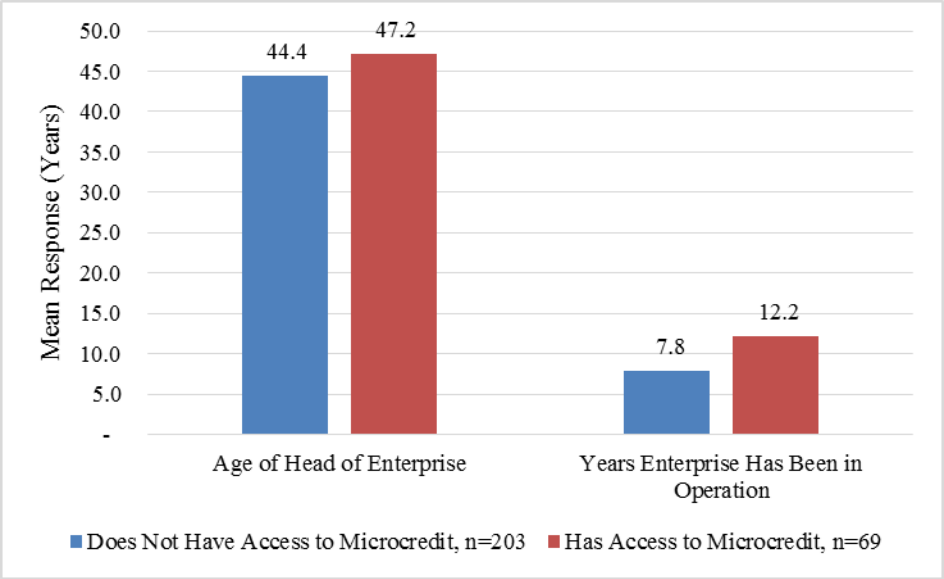


Figure 6. Proportion of Operations with Access to Microcredit



The average age of the head of an enterprise with access to microcredit was 2.8 years older than of enterprises without access to microcredit, as shown in Figure 7. Enterprises with access to microcredit had been in business for 4.4 years longer, on average, than enterprises without access to microcredit, also shown in Figure 7.

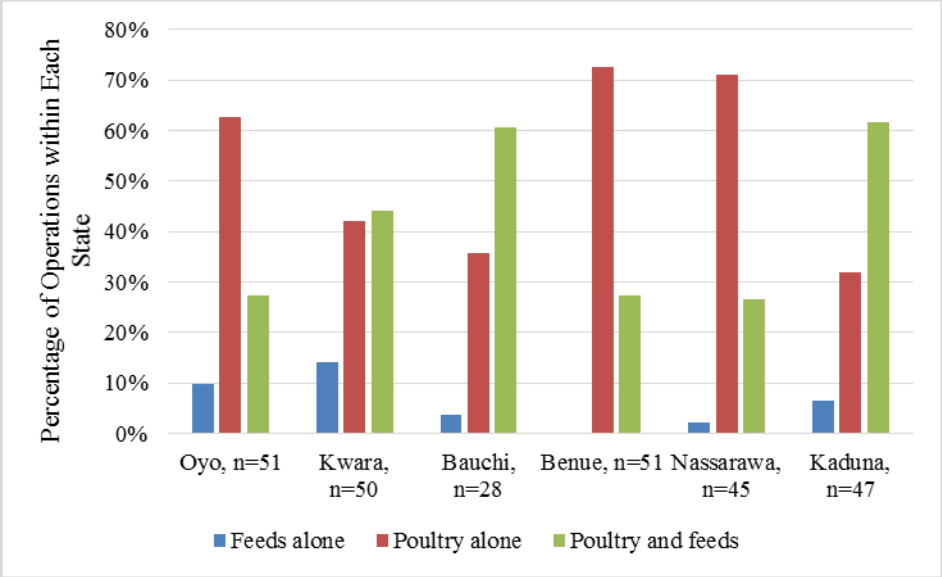
Figure 7. Differential Access to Microcredit



Demographic Differences Across States

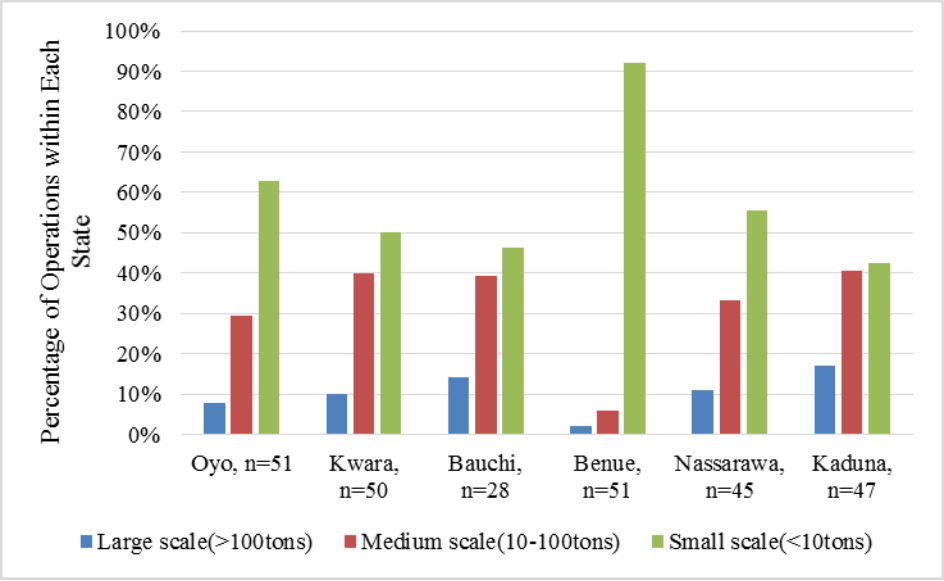
The percentage of companies, by state, producing poultry only, feed only and poultry and feed are illustrated in Figure 8. In this sample, there were three states – Kwara, Bauchi, and Kaduna – where the number of enterprises producing poultry and feed exceeded the number of enterprises producing poultry alone. In the other three states – Oyo, Benue, and Nasarawa, a substantially higher proportion of respondents produced poultry alone than produced poultry and feeds.

Figure 8. Products Made by State



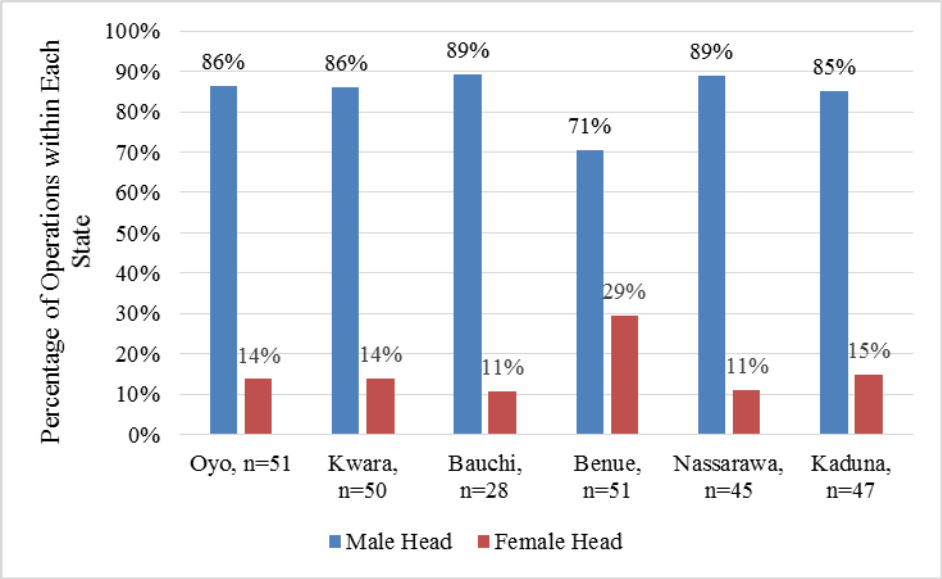
The percentage of businesses in each of the three size categories, by state, are illustrated in Figure 9. Small scale operations ranged from being just over 40% of the businesses in Kaduna State to over 90% of the businesses in Benue (green bars).

Figure 9. Scale of Enterprises within Each State



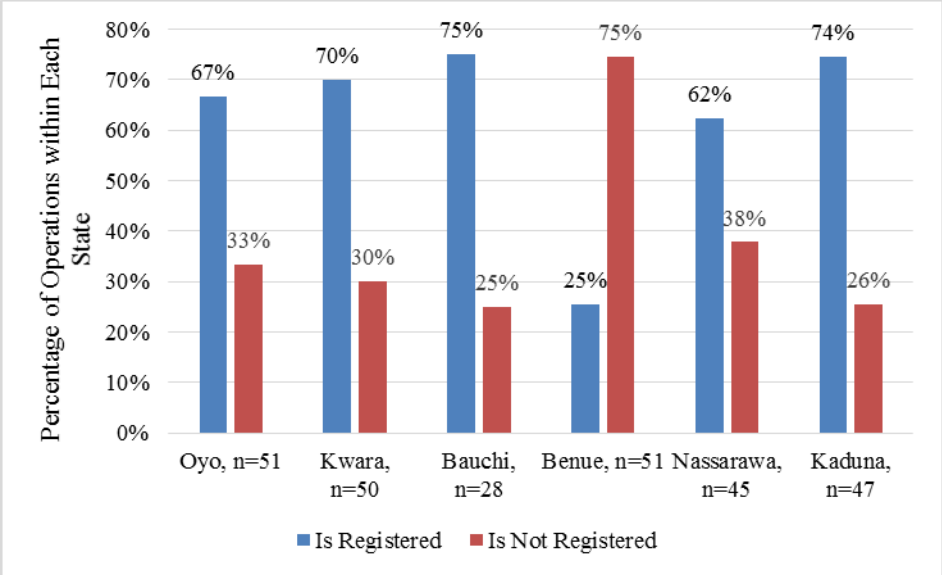
The percentage of enterprises with female heads is shown by the red bars in Figure 10. Twenty-nine percent of heads of enterprises in Benue were female, compared to a range of 11-15% for the other five states.

Figure 10. Gender of Primary Operator by State



The percentages of businesses that reported registering with local or state governments is presented in Figure 11. For all of states, except Benue, between 62% and 75% of the businesses were registered. In Benue only 25% of the businesses were registered.

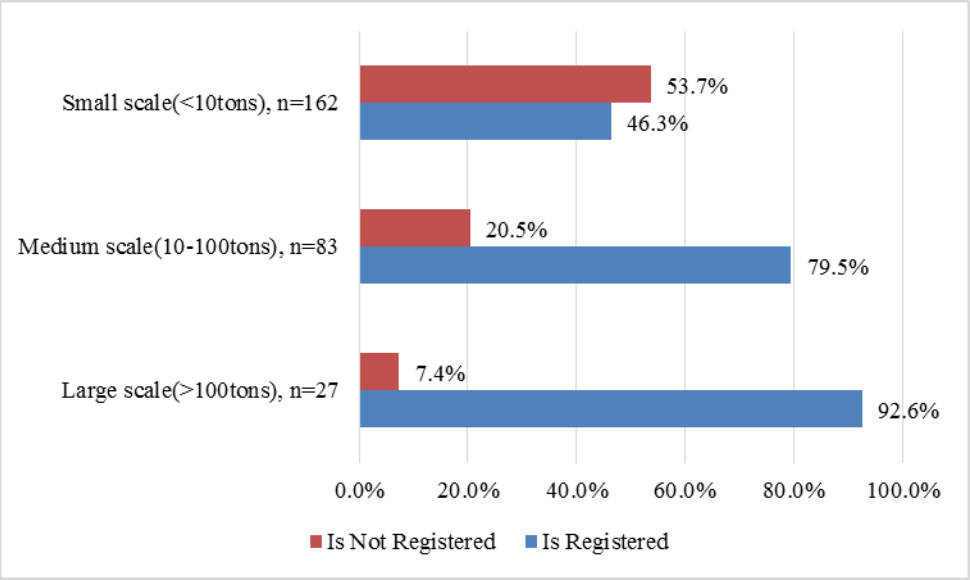
Figure 11. Registration with Local or State Gov't by State



Demographic Differences Across Scale

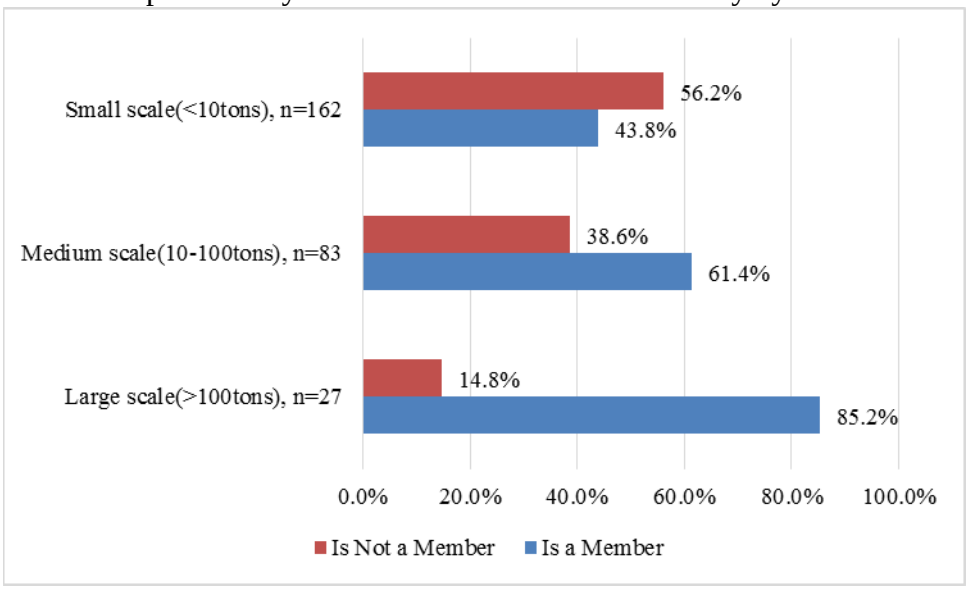
Differences in registration with local or state governments are further examined in Figure 12. Once again, the blue bars represent the percentage of businesses that were registered and the red bars represent those not registered. Registration rates were highest for large scale enterprises (92.6%), followed by medium scale enterprises (79.5%), and then small scale enterprises (46.3%).

Figure 12. Registration with Local or State Government by Scale



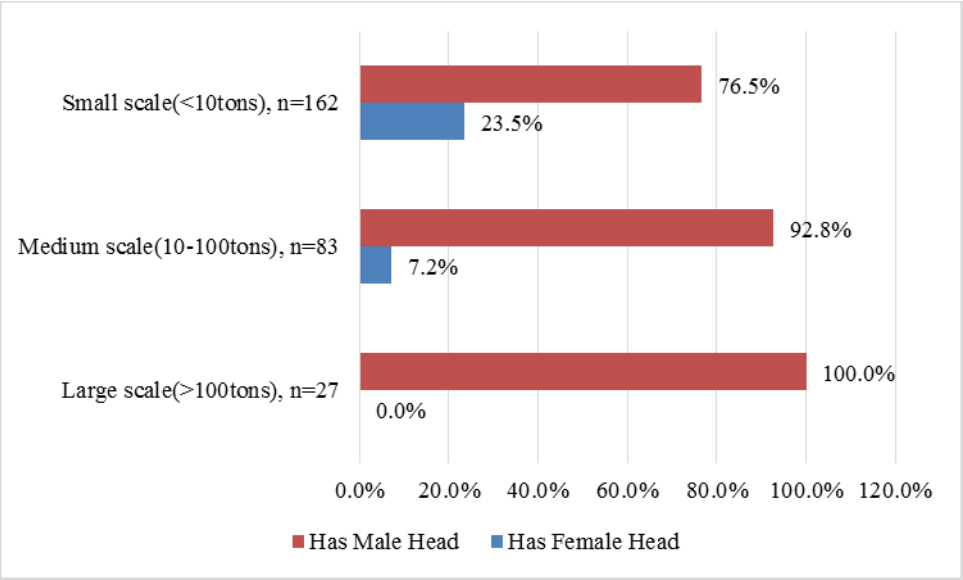
The blue bars in Figure 13 illustrate a similar pattern across scale in regards to membership in poultry associations or professional bodies. Over 85% of the large scale operations were a member of these associations, while 61% of medium scale enterprises and 44% of small scale enterprises had membership in these associations.

Figure 13. Membership in Poultry Associations or Professional Body by Scale



As shown in Figure 14, none of the large-scale enterprises had a female head. Just less than one-quarter of the small scale enterprises had a female head while only 7% of the medium-scale enterprises had a female head.

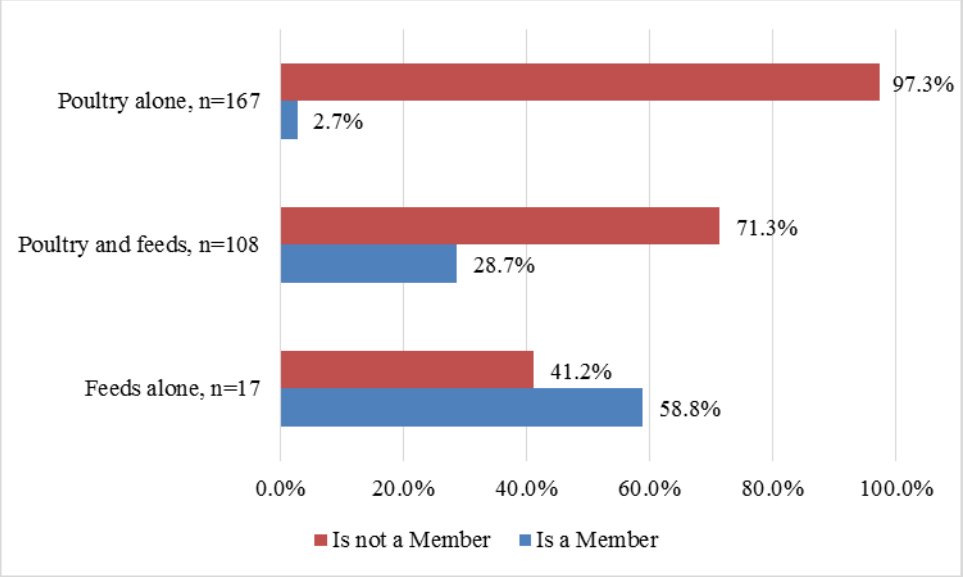
Figure 14. Gender of Head by Scale



Demographic Differences Across Products Made

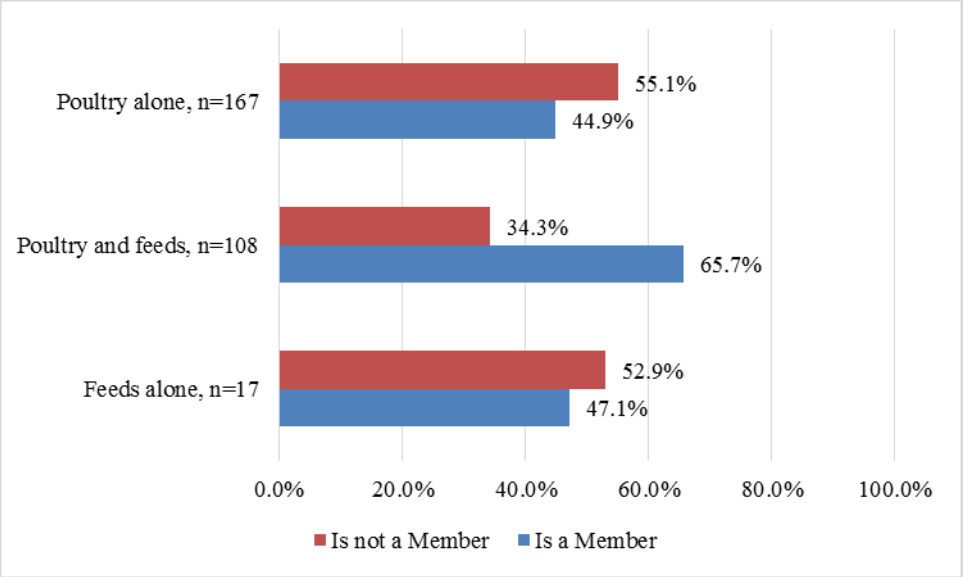
Membership in professional milling associations is illustrated in Figure 15 and membership in poultry associations is found in Figure 16. As shown by the blue bars in Figure 15, only 2.7% of enterprises producing only poultry were members of milling associations. Over half (58.8%) of enterprises producing only feed were members of milling associations.

Figure 15. Membership in Feed Miller Association or Professional Body by Products



As illustrated by the blue bars in Figure 16, 44.9% of enterprises producing only poultry and 65.7% of enterprises producing poultry and feeds were members of a poultry association. Interestingly, 47.1% of enterprises producing only feed were also members of a professional poultry association.

Figure 16. Membership in Poultry Association or Professional Body by Products

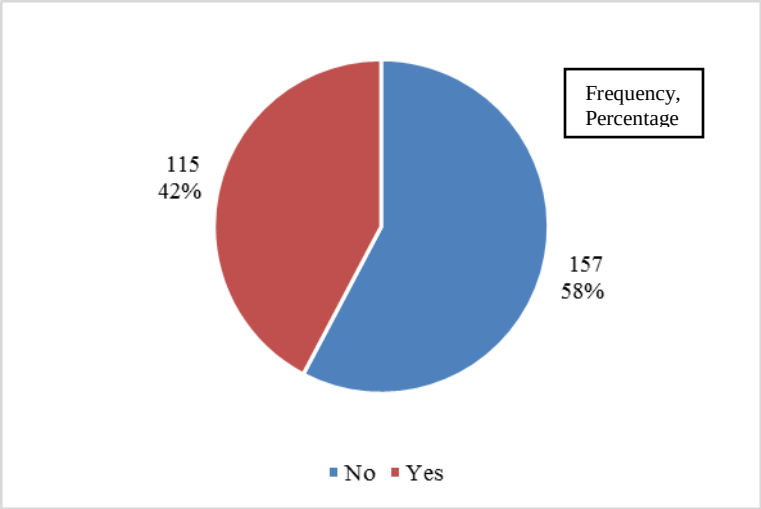


Aflatoxin and Aflasafe Awareness and Management

Respondents were asked a series of questions about their awareness of aflatoxin and Aflasafe and about their enterprise's current aflatoxin management strategies. The results to these questions are reported in Figures 17-20. Approximately 42% of respondents had heard of aflatoxin (red area of Figure 17). This was less than the percentage of poultry farmers who were aware of aflatoxin in 2005 in Benin (65.9%) and Ghana (81.6%) (James et al, 2007). In a similar survey administered

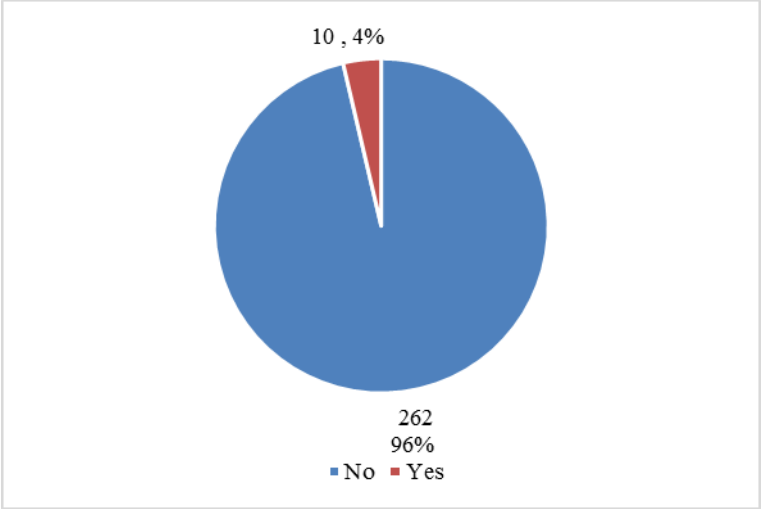
to Nigerian farmers concurrently with this survey, 72% of respondents had heard of aflatoxin (Johnson et al., 2017).

Figure 17. Have You Heard of Aflatoxin



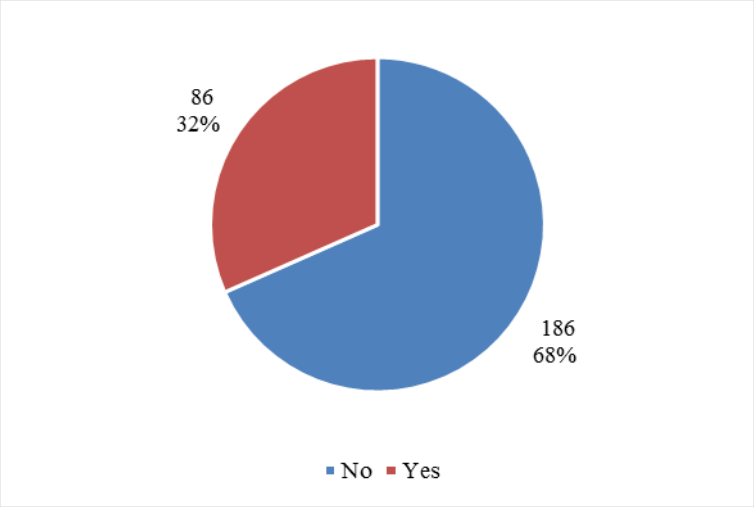
Respondents were asked to indicate whether they test the level of aflatoxin in their maize supply. Only 10 of the enterprises tested the level of aflatoxin in their maize supply, as shown by the red area of Figure 18.

Figure 18. Have You Been Testing for Aflatoxin Levels in Your Maize Supply?



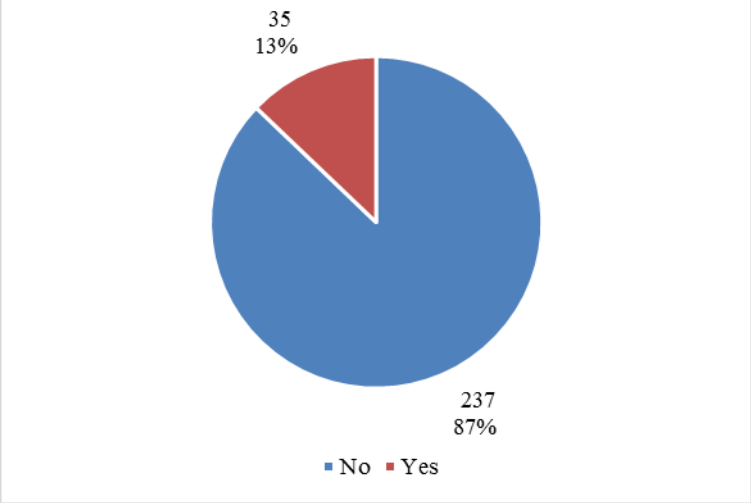
However, 86 enterprises (32%) did make an effort to control for the effects of aflatoxin contamination, as shown in Figure 19. The mechanisms enterprises used to control for aflatoxin are discussed in more detail below with Figure 22.

Figure 19. Do You Control for Aflatoxin in Your Maize Products?



Finally, 35 respondents, representing 13% of enterprises, had already heard of Aflasafe (Figure 20) (compared to 67% of farmers on the analogous survey mentioned above).

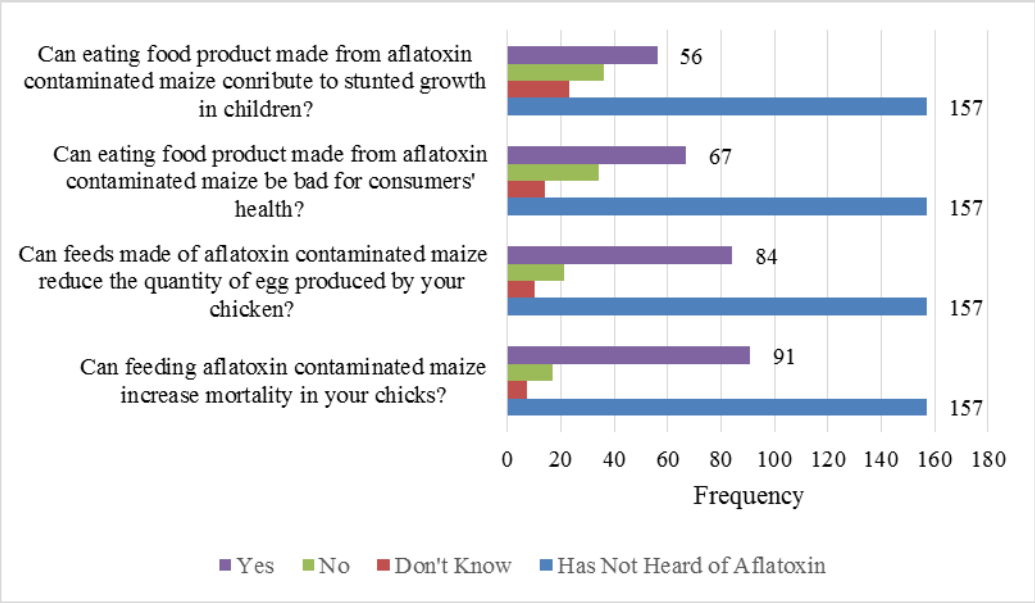
Figure 20. Have You Heard of Aflasafe?



Respondents' answers to questions about the consequences of aflatoxin consumption are displayed in Figure 21. The numbers of respondents who answered "yes" to each question are represented by the purple bars. While 91 respondents believed that feeding aflatoxin contaminated maize can increase mortality in chicks, only 56 respondents believed that eating aflatoxin contaminated food can stunt the growth of human children. Likewise, more respondents (84) believed that feeding aflatoxin contaminated maize can reduce the quantity of eggs produced by a chicken than believed eating aflatoxin contaminated food was bad for consumers' health (67). All of the respondents to this survey produced poultry or produce feed for animal consumption. None of the respondents to this survey milled maize for human consumption.

These results suggest that experience matters when it comes to recognizing the health consequences of eating aflatoxin contaminated foods. The respondents to this survey generally have more experience using maize for poultry consumption than for human consumption. More respondents recognized the negative health impacts of feeding contaminated maize to poultry than recognized the negative health impacts of eating aflatoxin contaminated maize on humans.

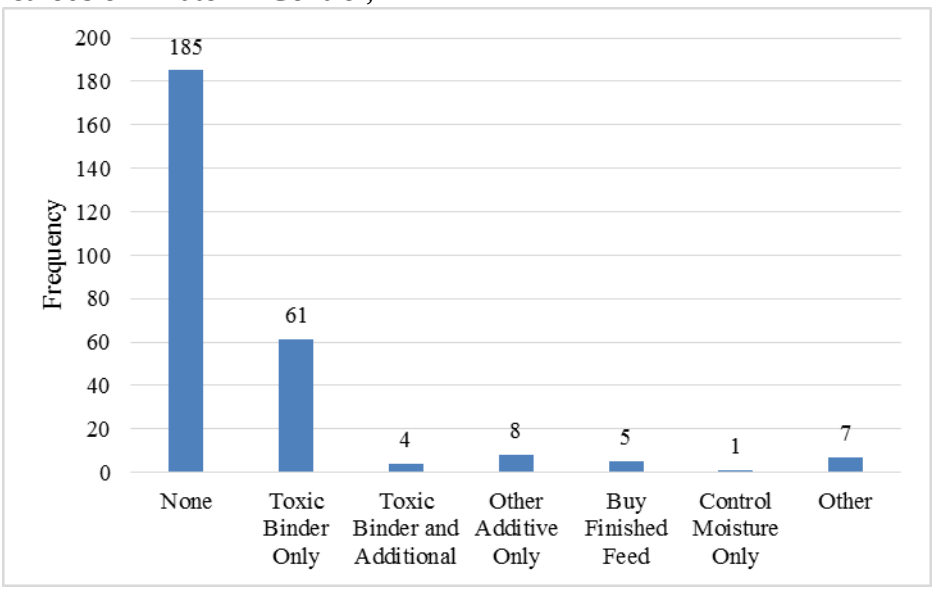
Figure 21. Aflatoxin Understanding, n = 272



A detailed examination of the strategies agribusiness enterprises implement to control the effect of aflatoxin contaminated feed is presented in Figure 22. The most frequently cited control strategy was adding a toxic binder to the feed ration, which was used by 65 enterprises. Certain clay minerals will chemically bind to aflatoxin and reduce the amount of aflatoxin absorption by the gastrointestinal system (Hell et al., 2008). Sixty-one of the 65 enterprises used toxic binder alone. Four of the 65 enterprises used toxic binder and an additional control strategy, such as other feed additives or drying maize.

Eight agribusiness enterprises incorporated other additives in their rations, including enzymes, yeast, and supa leaves. Five enterprises, all producing only poultry, controlled for aflatoxin by only purchasing finished feed. The number of poultry enterprises purchasing only finished feed may be understated due to respondents indicating that they do not control for aflatoxin because the enterprise itself does not incorporate additives or binder into its feed. One large-scale enterprise in Kwara monitors the moisture level of the maize it purchases.

Figure 22. Methods of Aflatoxin Control, n=271



Aflatoxin Awareness

A detailed breakdown of the level of aflatoxin awareness among different groups is presented in Table 3. There was clear variation in the level of aflatoxin awareness among states in this sample. The southwestern states of Oyo and Kwara had awareness levels substantially higher than the overall sample average.

Table 3. Aflatoxin Awareness

	% of each subgroup that has heard of aflatoxin	% of each subgroup that has NOT heard of aflatoxin
Full Sample, n=272	42.3%	57.7%
Decomposed by State		
Oyo, n=51	92.2%	7.8%
Kwara, n=50	70.0%	30.0%
Bauchi, n=28	32.1%	67.9%
Benue, n=51	23.5%	76.5%
Nassarawa, n=45	15.6%	84.4%
Kaduna, n=47	10.6%	89.4%
Decomposed by Type of Products Made		
Poultry Alone, n=147	34.7%	65.3%
Poultry and Feeds, n=108	47.2%	52.8%
Feeds Alone, n=17	76.5%	23.5%
Decomposed by Scale of Enterprise		
Small Scale (<10 Tons), n=162	37.7%	62.3%
Medium Scale (10-100 Tons), n=83	51.8%	48.2%
Large Scale (>100 Tons), n=27	40.7%	59.3%
Decomposed by Ownership Structure		
Sole proprietorships, n=239	40.2%	59.8%
Other ownership structures, n=33	57.6%	42.4%
Decomposed by Registration with NAFDAC		
Is registered, n=22	59.1%	40.9%
Is not registered, n=250	40.8%	59.2%
Decomposed by Registration with Local or State Government		
Is registered, n=166	50.6%	49.4%
Is not registered, n=106	29.2%	70.8%
Decomposed by Membership in Professional Poultry Association		
Is a member, n=145	53.1%	46.9%
Is not a member, n=127	29.9%	70.1%

When looking at the breakdown by the types of products made, enterprises that produced at least some feed have a higher level of aflatoxin awareness than enterprises that produced only poultry.

The results of the breakdown based on scale of enterprise are surprising in that large scale enterprises were less aware of aflatoxin than medium scale enterprises.

Sole proprietors in this sample had a substantially lower level of aflatoxin awareness than enterprises with other ownership structures.

Enterprises that were registered either with local or state government or NAFDAC had higher levels of aflatoxin awareness in this sample than enterprises not registered. Similarly, enterprises that were members of poultry associations have higher levels awareness than enterprises that were not members.

Aflatoxin Control

Table 4. Aflatoxin Management Practices

	% of each subgroup that controls for aflatoxin	% of each subgroup that does NOT control for aflatoxin
Full Sample, n=272	31.6%	68.4%
Decomposed by State		
Oyo, n=51	92.2%	7.8%
Kwara, n=50	46.0%	54.0%
Bauchi, n=28	17.9%	82.1%
Benue, n=51	17.6%	82.4%
Nassarawa, n=45	2.2%	97.8%
Kaduna, n=47	2.1%	97.9%
Decomposed by Type of Products Made		
Poultry Alone, n=147	25.1%	74.9%
Poultry and Feeds, n=108	32.4%	67.6%
Feeds Alone, n=17	52.9%	47.1%
Decomposed by Scale of Enterprise		
Small Scale (<10 Tons), n=162	25.3%	74.7%
Medium Scale (10-100 Tons), n=83	36.7%	63.3%
Large Scale (>100 Tons), n=27	32.1%	67.9%
Decomposed by Ownership Structure		
Sole proprietorships, n=239	29.7%	70.3%
Other ownership structures, n=33	45.5%	54.5%
Decomposed by Registration with NAFDAC		
Is registered, n=22	45.5%	54.5%
Is not registered, n=250	30.4%	69.6%
Decomposed by Registration with Local or State Government		
Is registered, n=166	38.0%	62.0%
Is not registered, n=106	21.7%	78.3%
Decomposed by Membership in Professional Poultry Association		
Is a member, n=145	42.8%	57.2%
Is not a member, n=127	18.9%	81.1%
Decomposed by Awareness of Aflatoxin		
Has heard of aflatoxin, n=115	74.8%	25.2%
Has not heard of aflatoxin, n=157	0.0%	100.0%

A breakdown of the percentage of enterprises that controlled for aflatoxin is presented in Table 4. While the proportion of enterprises that controlled for aflatoxin was 10.7% lower than the proportion of enterprises who have heard of aflatoxin for the sample overall, the trends within groups are largely the same in Table 4 as they are in Table 3.

Again, there is a substantial divergence of practices across states. In Oyo State, almost all enterprises controlled for aflatoxin contamination, while virtually none of the enterprises in Nasarawa and Kaduna States controlled for it. Again, agribusiness enterprises in this sample in Kwara and Oyo States controlled for aflatoxin contamination at the highest rates.

Overall, 74.8% of enterprises that had heard of aflatoxin also take steps to control for it in their feed supply.

Aflasafe Awareness

Table 5. Aflasafe Awareness

	% of each subgroup that has heard of Aflasafe	% of each subgroup that has NOT heard of Aflasafe
Full Sample, n=272	12.9%	87.1%
Decomposed by State		
Oyo, n=51	37.3%	62.7%
Kwara, n=50	10.0%	90.0%
Bauchi, n=28	0.0%	100.0%
Benue, n=51	11.8%	88.2%
Nassarawa, n=45	0.0%	100.0%
Kaduna, n=47	10.6%	89.4%
Decomposed by Type of Products Made		
Poultry Alone, n=147	12.9%	87.1%
Poultry and Feeds, n=108	12.0%	88.0%
Feeds Alone, n=17	17.6%	82.4%
Decomposed by Scale of Enterprise		
Small Scale (<10 Tons), n=162	11.1%	88.9%
Medium Scale (10-100 Tons), n=83	12.0%	88.0%
Large Scale (>100 Tons), n=27	25.9%	74.1%
Decomposed by Ownership Structure		
Sole proprietorships, n=239	11.3%	88.7%
Other ownership structures, n=33	24.2%	75.8%
Decomposed by Registration with NAFDAC		
Is registered, n=22	27.3%	72.7%
Is not registered, n=250	11.6%	88.4%
Decomposed by Registration with Local or State Government		
Is registered, n=166	16.3%	83.7%
Is not registered, n=106	7.5%	92.5%
Decomposed by Membership in Professional Poultry Association		
Is a member, n=145	18.6%	81.4%
Is not a member, n=127	6.3%	93.7%
Decomposed by Awareness of Aflatoxin		
Has heard of aflatoxin, n=115	26.1%	73.9%
Has not heard of aflatoxin, n=157	3.2%	96.8%

Awareness of Aflasafe is broken down in Table 5. Thirty percent less of the sample had heard of Aflasafe than had heard of aflatoxin. The trends follow a similar pattern as observed in Table 3 and Table 4.

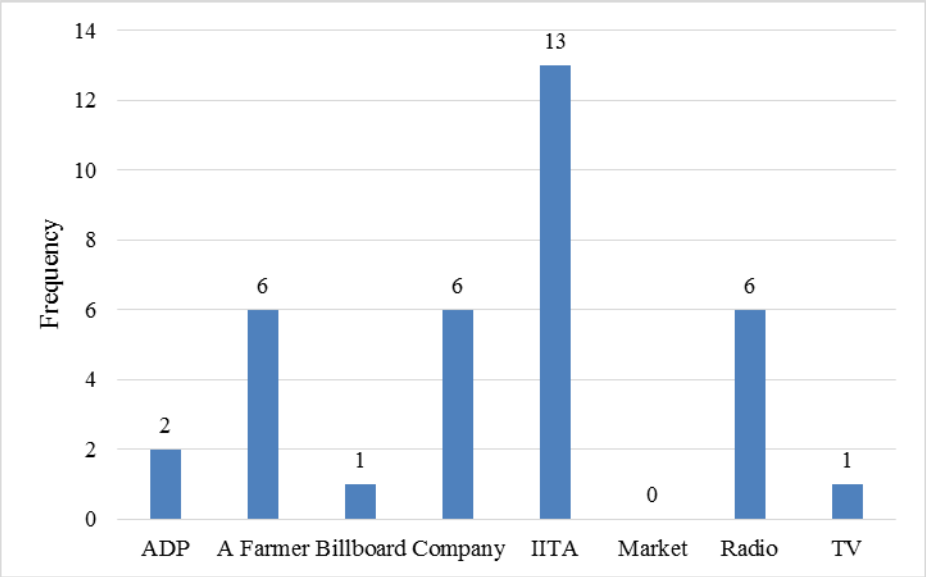
Heterogeneity across states continues to stand out. In Oyo State, over one-third of respondents knew of Aflasafe, but in Bauchi and Nasarawa States, none of the respondents knew of Aflasafe.

The percentages of enterprises producing poultry alone and poultry and feed whose representatives were aware of Aflasafe were very similar at 12% and 13% (Table 5). This result is in contrast to having heard of aflatoxin and controlling for aflatoxin contamination, where there were differences between poultry alone and poultry and feed enterprises. Similarly, small and medium scale enterprises had heard about Aflasafe at a similar rate just over 10%.

There was a small minority of enterprises that had heard of Aflasafe but not aflatoxin.

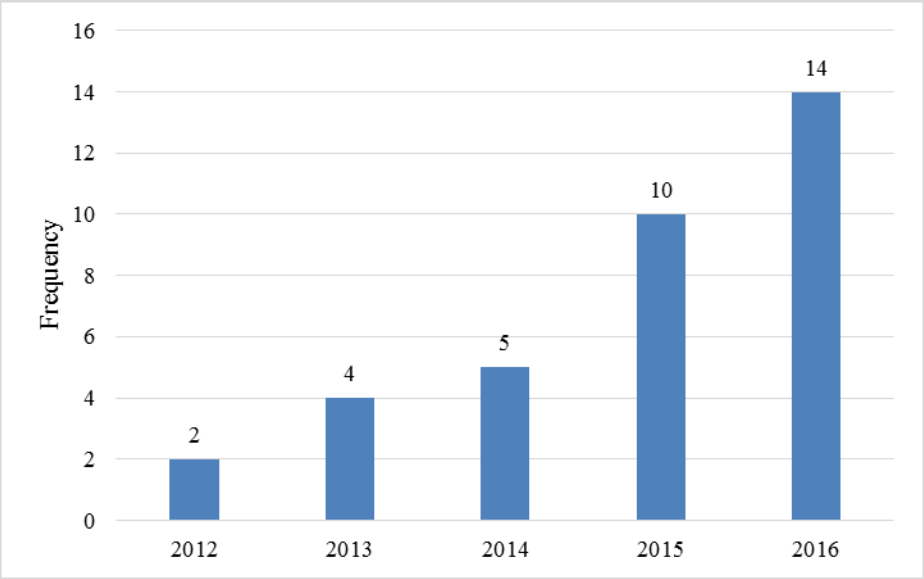
Respondents were asked to indicate where they heard of Aflasafe. The answers from the 35 respondents who heard of Aflasafe are reported in Figure 23. More respondents representing agribusinesses heard about Aflasafe from IITA than from any other source. Other leading providers of information include radio, farmers, and companies, potentially including implementers with the AgResults Nigeria Aflasafe pilot project. Farmers were asked the same questions on an analogous survey administered at the same time in the same states. A large percentage of farmers also learned of Aflasafe from IITA, farmers, and companies. However, radio was cited as an information source by 19% of agribusiness enterprises and only 7% of farmers, and ADP was cited as an information source by only 6% of agribusiness enterprises but by 20% of farmers (Johnson et al., 2017). This divergence in sources of information highlights the need for Aflasafe marketers to be thoughtful about the channels used to communicate with different audiences.

Figure 23. Where did you hear about Aflasafe? n=35



Similarly, respondents were asked what year they first heard about Aflasafe. Their answers are displayed in Figure 24. These responses can be compared to farmer responses on the analogous survey administered concurrently; in that survey of farmers, over 90% of sampled farmers in Benue, Kaduna, Kwara, and Oyo States had heard of Aflasafe (Johnson et al., 2017). Aflasafe awareness seemed to be growing more slowly among agribusinesses (agribusiness enterprises) than it is among farmers. Getting the word about Aflasafe out to agribusiness enterprises may be a key next step in the effort to promote widespread adoption of Aflasafe.

Figure 24. What year did you first hear about Aflasafe? n=35



Conclusion

Surveys were administered to poultry producers and feed millers in six Nigerian states: Bauchi, Benue, Kaduna, Kwara, Nasarawa, and Oyo. Numerous trends were observed in the demographic information obtained. Access to microcredit varied by gender, state, and tenure of enterprise. Enterprises with access to microcredit tended to have been in business longer (average = 12.2 years) than business without access (average = 7.8 years). Benue was an outlier from other states demographically. Benue had the most small scale enterprises, most female heads, and lowest level of registration with local or state government. A higher percentage of large scale enterprises than medium or small scale enterprises were registered with local or state government and were members of professional associations. A minority of enterprises (16%) were headed by women. This fact is most notable when considering large scale enterprises, none of which were headed by women. A higher percentage of feed milling alone enterprises joined professional poultry association (47.1%) than poultry alone enterprises join professional feed milling associations (2.7%).

Enterprises in some states were relatively more sophisticated in controlling for aflatoxin than enterprises in other states. For example in the southwestern states of Oyo and Kwara, 92.2% and 46.0% of enterprises respectively controlled for aflatoxin in maize supplies. In Nasarawa and Kaduna States, just over 2% of the enterprises control for aflatoxin. Overall, just less than one-third of enterprises controlled for aflatoxin in maize supplies, typically through the use of toxic binder. It was encouraging that 74.8% of enterprises whose representatives were aware of aflatoxin also had procedures to control for it.

Parallel differences across states are observed regarding the percentage of enterprise representatives that had heard of aflatoxin. At the high end, 92.2% of representatives in Oyo State had heard of aflatoxin, while only 10.6% of representatives in Kaduna State had heard of aflatoxin. It is noteworthy that Kaduna State had the lowest level of aflatoxin awareness even though implementers in Kaduna State were actively enrolled in the AgResults Nigeria Aflasafe pilot project in October of 2015 (AgResults Initiative, 2015). Awareness levels were higher in Bauchi,

Benue, and Nasarawa States than in Kaduna State, even though no implementers in those states were enrolled in the pilot project in October of 2015. Agribusiness awareness levels across states were not strongly correlated with the rollout of the pilot project.

A smaller percentage of poultry alone enterprises had heard of aflatoxin and Aflasafe than feed alone enterprises. Similarly, sole proprietors were less likely to have heard of aflatoxin and Aflasafe then representatives of enterprises with more complex ownership structures. Efforts to promote aflatoxin and Aflasafe awareness will benefit from tailoring to specific geographic and demographic groups.

It is interesting to note that the levels of aflatoxin and Aflasafe awareness were higher among enterprises registered with local or state governments than enterprises not registered. Similarly, enterprises that were registered with NAFDAC had higher awareness levels than enterprises that were not registered. Enterprises that were members of professional poultry association had higher awareness levels than enterprises that were not members. Local and state governments, NAFDAC, and professional poultry associations may all be channels for communicating information about aflatoxin and Aflasafe to agribusiness enterprise managers.

Only 4% of enterprises tested the level of aflatoxin in their maize supply. Controlling for aflatoxin to meet the objectives of increased health will require a cultural change, with testing being one of the first steps. Testing needs to be economical and accessible as a first step to seeing the benefits from aflatoxin control. Furthermore, only 13% of enterprise representatives had heard of Aflasafe. Awareness is the first step in the consumer adoption process (Littler, 2015). A decision maker needs to know about a product before he or she can do anything with it. More information about Aflasafe needs to be disseminated to the maize processing step of the value chain.

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Appendix

Questionnaire on ChoiceAflasafe for Poultry Owners (excluding choice experiment)

A. IDENTIFICATION

VARIABLE				
State:				
LGA:				
Town:				
Enumerator's Name:				
Name of the enterprise:				
Name of the respondent:				
Title of the respondent:				
Telephone number of the enterprise:				
Questionnaire ID:				
Date: DD_____MM_____YY				
Start time:				
GPS coordinates	Waypoint :	N(S)	E(W)	Altitude

GENERAL CHARACTERISTICS OF THE ENTERPRISE

1. Name of head of the enterprise: _____
2. Name of respondent_____
3. What is your position in the enterprise? _____
4. Does your enterprise make use of maize grain? 1= Yes 0= No
5. Age of the head:_____ years
6. Gender of the head: 1= Male, 0= Female
7. Marital status of the head 1= Single 2= Married 3= Others
8. Level of education of the head: 1= Formal Education 0= No formal education
9. Number of years of education of respondent_____ years
10. What is the legal status of the enterprise? 1=Registered; 2=Unregistered; 3=Other (Specify)_____
11. What is the type of the enterprise? 1= Sole proprietor; 2= Partnership; 3= Cooperative/ Association; 4 = Private Limited Co;5= Public company;6=Joint (private & public);7= Other (Specify)_____
12. Would you characterize your enterprise as small, medium, or large based on the quantity of maize you use per annum. 1= Small scale (<10tons) 2=Medium scale (10 -100tons) 3=Large scale >100tons)
13. What type of product do you make? 1. Poultry & feeds 2. Feeds alone 3. Poultry alone 4. Maize based food products
14. For how many years has your enterprise been operating? _____
15. Is your operation registered with NAFDAC (0=No 1=Yes)
16. Is your operation registered with Local/State government? (0=No 1=Yes)
17. Net revenue per year for the enterprise ₦_____
18. Does your enterprise belong to any poultry associations or professional body? (1 = Yes, 0 = No)
19. Does your enterprise belong to any feed miller associations or professional body? (1 = Yes, 0 = No)
20. If yes for how many years have it been a member? _____
21. Does your enterprise have access to micro-credit for boosting business? (Yes.=1; No = 0)

INFORMATION AWARENESS & COMMUNICATION

22. Have you heard about aflatoxin? (0=No 1=Yes)

If yes, answer questions in the table below

Variable	**1=Yes, 2=No, 3= Don't know**
Can feeding aflatoxin contaminated maize increase mortality in your chicks?	
Can feeds made of aflatoxin contaminated maize reduce the quantity of egg produced by your chicken?	
Can eating food product made from aflatoxin contaminated maize be bad for consumers' health?	
Can eating food product made from aflatoxin contaminated maize contribute to 'stunted growth' in children?	

23. Have you been testing for aflatoxin level in your maize supply? (0=No 1=Yes)
24. If you are testing for aflatoxin, what testing methods do you use?

    _____
25. Do you control for aflatoxin on your maize products? (0=No 1=Yes)
26. If you control for aflatoxin in your maize products, please describe what you do.

    _____

    _____
27. Did you have experience paying a price premium for delivery of aflatoxin reduced maize? (0=No 1=Yes)

    If yes, indicate the price premium in below table

Price Premium

Years	**What price premium did you pay**	**`Maize quality**
2015 – Lean season	_____%	- 4 ppm - 10 ppm - 20 ppm - Not tested
2015 – Planting season	_____%	- 4 ppm - 10 ppm - 20 ppm - Not tested

28. Have you heard about aflasafe? (0=No 1=Yes)

    If yes, attend to the table below

	Response
When did you first hear about it?(e.g. 2001)	
Where did you hear about it?(TV, Radio, another farmers, billboard, IITA, ADP, Company, others)check all that apply	

29. From the table below, what months do you typically buy maize?

Months	**1=Yes, 0=No**
November	
December	
January	
February	
March	
April	
June	
July	
August	
September	
October	
November	
December	

30. Relationship with implementer (see the table below)

Years	**Are you an implementer with AgResults? Yes=1, no=0**	**Are you working with an implementer (yes or no)**	**If yes, Name of implementer**
2016			
2015			
2014			
2013			
2012			