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J. M. Malusha, MSc, Post graduate, Jomo Kenyatta University of Agriculture and Technology (JKUAT), M. Karama, PhD, Professor, Kenya Medical Research Institute (KEMRI), Centre for Public Health Research and A. O. Makokha, PhD, Professor, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Department of Food Science and Technology, P.O. Box 62000, Nairobi

THE INFLUENCE OF HOUSEHOLD SOCIO-ECONOMIC CHARACTERISTICS AND AWARENESS ON AFLATOXIN CONTAMINATION OF MAIZE IN MAKUENI COUNTY, KENYA

J. M. MALUSHA, M. KARAMA and A. O.MAKOKHA

ABSTRACT

***Background*: Aflatoxicosis resulting from consumption of contaminated maize poses a significant public health problem in many countries including Kenya, and many people living in developing countries could be chronically exposed to aflatoxin through their diet. It is caused by Aflatoxins produced by fungus of species *Aspergillusparasiticus* and *Aspergillus flavus* found mainly in cereals and other foodstuffs.**
***Objective*: To determine socio-economic and aflatoxin awareness factors associated with aflatoxin contamination in household maize in Makueni County, Kenya.**
***Design*: A comparative descriptive analytical study.**
***Setting*: Kibwezi and Kilome sub-counties of Makueni County, Kenya.**
***Subjects*: Four hundred and fifty household heads or their representatives with maize in their household stores, comprising 225 from each study site.**
***Results*: Majority of the households' main source of income was farming and most of them were poor, but level of awareness on aflatoxin was very high. The results further showed significant associations of some socio-economic characteristics and awareness with aflatoxin contamination of maize. Gender of household head was significantly associated with proper maize storage. Age of respondent was found to be significantly associated with knowledge/awareness of aflatoxin and knowledge on signs of suspected aflatoxin contaminated maize. There was significant association between age of respondent and perception on whether altitude/climate affected aflatoxin contamination, level of education and knowledge/awareness of aflatoxin. Level of education was significantly associated with Knowledge on identification of contaminated maize as well as on Knowledge on signs of aflatoxin. Besides, level of education was significantly associated with proper ventilation, discoloration of maize, and maize in storage affected by pests/insects, and cleaning of maize prior to storage. There was also significant association between occupation of respondent and proper maize storage. Income of house hold head was significantly associated with knowledge/awareness on aflatoxin. Knowledge/awareness of aflatoxin problem was also significantly associated with placing of material underneath of maize during drying, cleaning of maize prior to storage, moldy condition of maize, aflatoxin content in maize and proper maize storage.**
***Conclusion*: These study findings imply that efforts to control and prevent aflatoxin contamination of maize should take into consideration socio-economic characteristics as well as aflatoxin awareness. Thus reducing poverty levels by raising income, education levels and awareness of the community will most likely have a profound impact on control of aflatoxin. There is need, therefore, for policy makers and stakeholders to promote household positive socio-economic factors and aflatoxin awareness in households. This can greatly contribute to reduction of aflatoxin contamination in maize.**

INTRODUCTION

Aflatoxicosis resulting from consumption of contaminated maize poses a significant public health problem in many countries including Kenya. It is estimated that 4.5 billion people living in developing countries could be chronically exposed to aflatoxin through their diet (3). Aflatoxins are secondary metabolites from mould of the Aspergillus family and include among others Aspergillusparasiticus and Aspergillusflavus and they produce aflatoxins which contaminate cereals and other foods (1).

In Kenya, the eastern region particularly Makueni has been mostly affected by aflatoxicosis outbreaks resulting from consumption of maize contaminated with aflatoxins. Makueni has experienced three major outbreaks since 1981 to date (2, 18, 15, 13). This has necessitated authorities and stakeholders to undertake numerous strategies at various levels to control aflatoxin problem. One of the strategies was addressing improvement of maize pre-storage practices. Improvement of post-harvest handling of maize which includes pre-storage practices has been known to reduce or minimize aflatoxin contamination. Moreover this can also greatly reduce maize losses resulting from post-harvest handling inefficiencies and storage (17, 19). Regulatory authorities have also set regulatory limits of aflatoxin contamination in foods including maize to 10ppb in order to control aflatoxin poisoning (10, 4).

Aflatoxin occurrence in maize can be minimized by sound agricultural, pre-harvest, harvest, drying and storage practices since aflatoxins can develop rapidly in fungal infected maize. Studies carried out previously in the affected area, revealed that aflatoxicosis was acquired from eating contaminated maize attributed to improper harvesting, drying and storage of maize (18, 15).

In addition, drying of crops properly before storage as well as sorting and disposing of visibly moldy or damaged kernels before storage, can prevent or reduce the development of aflatoxins in postharvest drying and storage, although this does not eliminate them (9).

At harvest, majority of farmers store most of their maize for household consumption while selling some to meet other household needs. This underscores the need for proper harvesting, drying and storage of maize. However adoption and practice of proper household maize storage as well as proper harvesting and drying for prevention and control of aflatoxin contamination in maize could be influenced by household socio-economic and awareness factors. This paper therefore reports the findings of a study conducted to determine household socio-economic characteristics and awareness on aflatoxin, and the influence of these on aflatoxin contamination of maize, in Makueni County.

MATERIALS AND METHODS

Description of study sites: This study was conducted in Kibwezi and Kilome sub-counties of Makueni County. Kibwezi study site is a lower altitude area located at S02.40157, E037.95143 SW, at an altitude of 916m above sea level, while Kilome study site is a higher altitude area located at S01.84098, E037.31536NE at an altitude of 1750M above sea level. Makuenicounty covers an area of 8,034.7 square Km and according to 2009 population census it had a population of 884,527(7), which in 2012 was projected to 922,183 with estimated annual population growth of 1.4% (16). Physiographically, the land rises from 600m above sea level at the southern parts of the county which include Kibwezi and Makindu which are low-lying areas, to 1900 m above sea level in northern highest parts of the county which include Kilome and Kilungu hilly areas (7). Due to change in altitude, the county has climatic variations and extreme differences in temperatures. The northern part is usually cool while the southern part with low-lying areas is usually hot. The mean temperatures in this area range from 20.2 to 24.6 degrees centigrade. The county experiences two rainy seasons, namely: the long rains season occurring in March/April and the short rains season occurring in November/December. The main food crops produced are maize, beans, cow peas and pigeon peas in that order, with maize being a staple food.

Study design and Setting: This was comparative analytical study to determine aflatoxin contamination of household maize. Study setting was in Kibwezi and Kilome sub-counties of Makueni County.

Sampling of households: Two geographically and ecologically different zones namely Kibwezi and Kilome were purposefully selected for this study for comparison purposes. In each zone, one geographical location was randomly selected. Representative sample of households was then selected from Sub-locations/cluster based on method of probability proportional to size.

At each of the two zones studied, households storing maize were selected to create a sample which included all types of maize in households representing each study area. Households, which were the sampling units, were then selected at random through systematic random sampling methods using a sampling frame and a table of random numbers. The households' heads who consented to participate in the study were then recruited.

The study and target populations comprised people in households in study areas who store home grown maize in their households. It included all adults (above 18 years of age) who are household heads or their representatives within the study area and store home grown maize. It also included, agricultural and public health workers working in the area as well as community informants who consent to participate in the study. The study excluded people below 18 years of age and households which do not store home grown maize.

The sample size for households selected was be determined using a formula as used by Fisher et al. (1998) which gave a minimum of 225 households for each study site.

A further sub-sample of 10% of the 225 households in each study site with stored home grown maize was selected and maize samples were collected for analysis from these households.

Sampling was achieved by first getting the random starting household in which random numbers were used to pick up the starting household. The remaining households of the sample were then selected at fixed nth intervals determined by dividing total number of households by sample size. After selecting the household, the purpose, nature, procedure and expected benefits of study were explained to the household owner/head after which consent was sought and if he/she consented was then requested to sign the consent form and after which he/she was recruited to participate in the study.

All Sampled households owners/heads with home grown maize were administered a face-to-face interview using structured interview schedule. A representative sub-sample comprising 10% of 450 households sampled were drawn through systematic random sampling method. These households were requested to provide samples of their stored home grown maize for moisture content determination and aflatoxin analysis. The sub-sampled households were later followed for collection of samples in the next seasons harvest in order to take into account seasonal variations.

Data Collection: Questionnaires/interview schedules, checklists, in-depth interviews schedules and focus group discussion guides were used to collect data from the study sites. Questionnaires/Interview schedules were used to obtain data from respondents in either Kiswahili, kikamba, or English, but the recording was in English. Information collected using questionnaires/interview schedules included 1) socio-demographic information such as sex, age, marital status, religion, level of education, occupation, economic status, 2) knowledge and awareness on aflatoxin, 3)maize pre-storage practices (as could be recalled by the household owner), and 4) maize storage practices. A checklist was used as a guide for collection of information on visual assessment of condition of maize as observed during storage as well as the condition of the storage structures.

Focus group discussions (FGDs) with key community opinion leaders/informants using FGD guides and in-depth interviews with agricultural and public health workers were conducted to corroborate information collected using questionnaires/interview schedules.

Two FGDs, one in each study site, were conducted each comprising 15 people. One FGD was conducted in Kibwezi area while the other was conducted in Kilome area. Each FGD comprised of selected local opinion leaders which included women group leaders, youth group leaders, village leaders and other key stakeholders in the study area. Collection of data using questionnaires and taking of maize samples were done in November following first season maize harvest.

Maize sampling: Maize samples were obtained from 10 % of sub-sampled households with maize which were selected for study and interviewed using structured interview schedules/questionnaires. A one kg of maize sample was taken from maize found in the sub-sampled household. The sample was taken in such a way that it was a representative of the lot. Samples were collected from maize intended for human consumption found in the household. In case of maize packed in small volumes in different bags, multiple samples were taken from different parts of one bag or several bags belonging to one household and combined to produce a one kg sample for analysis. The maize samples were collected using sampling tools such as scoops/probes and put in paper bags, and carried and stored in paper bags while awaiting analysis. Each sample had a sampling form filled with specific identification information pertaining to the sample. Maize samples were collected in households in November 2103 after first season maize harvest and in May 2014 after second season maize harvest.

Maize sample analysis: Moisture content was taken at the field during collection of maize samples and was determined using Portable Grain Moisture Tester. Before laboratory analysis, the maize samples were visually inspected for insect/pest infestation, mold or discoloration. Moisture content was taken at the field during collection of maize samples and was determined using Portable Grain Moisture Tester. Before laboratory analysis, the maize samples were visually inspected for insect/pest infestation, mold or discoloration. The analysis of maize samples for aflatoxin was done using ELISA test to determine presence of total aflatoxin content. The procedures for moisture content determination and ELISA test are briefly described here below.

Moisture Content Determination: Nine (9)v battery was put in the moisture tester and P button pressed for 1 second to check if it was working, after the previous data of moisture content reading has been erased by Pressing F button constantly. Seventy (70) g of maize sample was then taken, well shaken and filled into moisture device to flash level and corked tightly. The moisture Tester device was then powered on by pressing P button. Appropriate scale depending on grain, was then chosen and this case since the grain was maize the scale was 1-16. The sample was then allowed to run in the device for one minute and then the moisture content was read, after which the F key button was pressed to save the reading.

A new test for a different sub-sample from the same sample was repeated to give an average reading for the sample, which was then recorded. After each reading was noted, the F button was constantly pressed for 8 Seconds to ease previous reading from memory before doing a new test. For each different sample taken the same procedure was followed.

Determination of Aflatoxin contamination: Determination of Aflatoxin contamination was done using Enzyme Linked Immunoassay (ELISA) test. Description of ELISA test is as stated here below.

Enzyme Linked Immunoassay (ELISA) test: Extraction of Sample was done by taking 0ne kg of maize sample and grinding it into flour with a mill and then homogenizing it. Then 20g homogenized sample were weighed and 20ml of 70% Methanol were added into the sample. They were mixed for two hours and filtered using Buchner funnel. The extraction jar was then rinsed with 20 mls of extraction solution. The total volume of the extract was then measured and recorded.

Column Preparation was done by taking five (5) g in 25 mls (70% methanol) of extract and adding 10 % of methanol in prepared Phosphate Buffered Saline (PBS). Then 5ml of 10% methanol PBS were passed through without letting it dry. A sample comprising 1ml of extract and 6ml water was then applied and let run slowly at the rate of 1 drop in 3 seconds. Distilled water-15ml was then applied and passed slowly at rate of I drop per second. Then air was passed to dry and the column was put to a receptacle for eluent. One (1) ml methanol (100 %) was then applied and passed slowly into receptacle.

Cleaning up was done with Acetonitrile. Nine (9)mls of sample extract were taken and evaporated to dryness with nitrogen/rotavapour. It was then diluted with PBS buffer to 10mls (the amount of organic solvent did not exceed 5% of solution). The extract solution was then filtered and dropped off onto the immumo-affinity column at the rate of 1-3ml/min. The Immuno-affinity column was washed with 2*10ml water and the water dropped through the column with gravity. The column was dried to ensure total Aflatoxins recovery.

Derivatisation was done by evaporating all samples to dryness and then 200ul TFA were added and incubated at RT for 40 minutes, after which 800ul Acetonitrile: water (30:70) was added and dissolved using a sonicator. They were then filtered through a membrane filter (GHP 0.2um) into a vial.

Enzyme Linked Immunoassay ELISA Analysis: A sufficient number of micro-titer wells were inserted into the microwell holder for all standards and samples run in duplicate. Standard and sample positions were recorded. Then 50 μl of the standard solutions or prepared sample were added to separate duplicate wells, and 50 μl of the enzyme conjugate were then added to each well. Then 50 μl of the antibody solution were added to each well and mixed gently by shaking the plate manually and incubating for 30 minutes at room temperature (20-25◦C). The liquid was then poured out of the wells and the microwell holder tapped upside down vigorously (three times in a row) against absorbent paper to ensure the liquid from the wells was removed completely.

All the wells were filled with 250 μl washing buffer 10.1 and the liquid poured out again. The the washing procedure was repeated two times. After which 100 μl of substrate/chromogen (brown cap) were added to each well and mixed gently by shaking the plate manually and incubating for 15 minutes at room temperature (20-25◦C) in the dark. Then 100 μl of the stop solution were added to each well and mix gently by shaking the plate manually and the absorbance measured at 450 nm. Reading was done within 30 minutes after adding stop solution.

Data Management and Analysis: Data were cleaned, coded and entered in MS Windows Excel software and then transferred to SPSS for Window version 17.0 (SPSS Inc., Chicago, Illinois) for Statistical analyses. Analysed data (results) are presented using percentages, frequency tables, bar charts, and Pie charts. Descriptive statistics such as frequencies and means were applied in order to group and summarize data to facilitate presentation.

Chi-square test for independence was used to determine association of categorical variables such as age, education, occupation, maize storage and pre-storage practices. Pearson Correlation coefficient was used to analyse relationships of quantitative variables. Tests of significance were at α 0.05 level of significance, and confidence levels at 95%. Quality of data was ensured by proper sampling, collection and analysis at all stages of research.

RESULTS

Household Socio-economic and demographic characteristics: The household respondents who were heads of households or their representatives had mean age of about 47 years in both study sites. Majority of respondents were female (58%) and most of them were married (74.2 %). Majority of them had attained primary education (61.7%). The main occupation of respondents was farming (79.2%) and farming was their main source of income for households (75.0%)) with majority of them (68.4%) earning less than Ksh.5000 (mean income was Ksh.4797), implying that majority of the people were poor and this is supported by information in County development profile (16). Households had an average of six people. Table 1 shows household socio-economic characteristics.

Table 1

Household Socio-economic Characteristics

Household Socio-economic characteristic (N=240)	Kibwezi study site	Kilome study site	Average for the two study sites
Mean age of household respondents in years	47.4	46.5	46.9
Marital status of majority of respondents-married (frequency and %)	165(68.8)	191(79.6)	178(74.2)
Main education level of majority of respondents-primary (frequency and %)	156(65.0)	140(58.3)	148(61.7)
Main occupation of majority of respondents-farming (frequency and %)	196(81.7)	184(76.7)	190(79.2)
Main source of income of households-farming (frequency and %)	182(75.8)	178(74.2)	180(75.0)
Mean income of households (Kshs)	4862.9	4731.3	4797.1
Household income range of majority-KShs 1 to 5,000(frequency and %)	175(72.9)	153(63.8)	164(68.4)

Respondent's Knowledge and awareness on Aflatoxin Contamination of Maize: Respondents Knowledge/awareness on Aflatoxin contamination of maize was assessed using sub-variables which included level of awareness on aflatoxin and source of information on the same, knowledge on identification of maize suspected to be contaminated with aflatoxin as well as knowledge on prevention of aflatoxin contamination of maize.

In this study, level of awareness on aflatoxin was 92.9%, and main source of information for majority of respondents was through electronic media (56.7 %). About 93.1% of respondents said they could identify aflatoxin contaminated maize and 91.3% said they knew signs of maize suspected to be contaminated with aflatoxin. In addition 67.3% of respondents identified green color as the main sign of maize suspected to be contamination with aflatoxin. An estimated 86.8% of respondents considered proper drying and storage of maize as the main ways of preventing aflatoxin contamination. Table 2 shows Respondent's Knowledge and awareness on Aflatoxin Contamination of Maize.

Table 2

Respondent's Knowledge and awareness on Aflatoxin Contamination of Maize

Respondents Knowledge/awareness on Aflatoxin (N=240)	Kibwezi study site	Kilome study site	Average of two study sites
Level of awareness on aflatoxin (frequency and %)	224(93.3)	221(92.5)	223(92.9)
Main source of information for higher proportion of respondents-Electronic media (frequency and %)	116 (48.3)	156(65.0)	136(56.7)
Respondents who said could identify maize suspected to be contaminated with aflatoxin (Frequency and %)	230 (95.8)	217 (90.4)	224(93.1)
Respondents who said knew signs indicating possibility of aflatoxin contamination in maize (frequency and %)	209(87.1)	229(95.4)	219(91.3)
Perception on main sign of aflatoxin contaminated maize-green color (frequency and	120 (57.4)	177(77.2)	149(67.3)
Respondents who considered proper drying and storage as main aflatoxin prevention measures (frequency and %)	202(84.1)	215(89.5)	209(86.8)

Association of Socio-Economic Variables with Aflatoxin Contamination of Maize: Socio-economic variables were analyzed with aflatoxin contamination variables to determine their associations/correlations. In Kibwezi Gender/sex of respondent was significantly associated with proper maize storage (ie maize stored either in raised platform, granary, traditional cribs or improved cribs) ($\chi2,1$ =6.253,P<0.05), while in Kilome the association was not significant ($\chi2,1$=0.155, P>0.05). Age of respondent was found to be significantly associated with knowledge/awareness of aflatoxin in Kibwezi ($\chi2$, 63=89.42,P<0.05). Age of respondent was also significantly associated with knowledge on signs of suspected aflatoxin contaminated maize in Kibwezi ($\chi2,63$ =86.741, P<0.05) and Kilome ($\chi2,55$=3.147,P<0.05)

There was significant association between age of respondent and perception on whether altitude/climate affected aflatoxin contamination in Kibwezi (Correlation r238=0.156, P<0.05) and Kilome (Correlation r,238=0.141,P<0.05); level of education and knowledge/awareness of aflatoxin in Kibwezi ($\chi2,3$ =8.865,P<0.05). Level of education was significantly associated with Knowledge on identification of contaminated maize in Kibwezi ($\chi2,1$=8.865,P<0.05). Association was significant between level of education and Knowledge on signs of aflatoxin in Kibwezi ($\chi2,3$=9.490,P<0.05). In Kibwezi level of education was significantly associated with proper ventilatioin ($\chi2,3$ =14.732,P< 0.05), discoloration of maize ($\chi2,3$ =8.207, P<0.05), maize in storage affected by pests/insects ($\chi2,3$=7.132, P<0.05), and cleaning of maize prior to storage ($\chi2,3$ =8.626, P<0.05), while in Kilome level of education was significantly associated with maize in storage affected by pests/insects ($\chi2,3$ =7.864, P<0.05), and cleaning of maize prior to storage ($\chi2,3$=8.626, P<0.05). There was significant association between occupation of respondent and proper maize storage in Kibwezi ($\chi2,43$=61.929,P<0.05). Income of house hold head was significantly associated with knowledge/awareness on aflatoxin both in Kibwezi ($\chi2,4$=12.527, P<0.02) and Kilome ($\chi2,4$=37.366, P<0.001).

Association of Knowledge/Awareness on Aflatoxin with Aflatoxin contamination in maize: Knowledge/awareness on aflatoxin variables were analyzed with aflatoxin contamination variables to determine their associations/correlations. Knowledge/awareness of aflatoxin problem was associated with knowledge on signs of aflatoxin both in Kibwezi ($\chi2,1$ =4.117, P<0.05) and In Kilome ($\chi2,1$ =34.384, P<0.001). In Kibwezi Knowledge/awareness of aflatoxin problem was associated with Perception on health problems linked to consumption of aflatoxin contaminated maize ($\chi2,1$ =18.634, P<0.001), Knowledge on identification of contaminated maize ($\chi2,1$ =5.497,P<0.02), maize affected by pests/insects ($\chi2,1$ =4.86, P<0.05), removal of outer cover of maize cob(correlation r 238=0.146, P<0.05), while in Kilome Knowledge/awareness of aflatoxin problem was associated with Perception on health problems associated with aflatoxin contaminated maize ($\chi2,1$ =17.694, P<0.001).

Knowledge/awareness of aflatoxin problem in Kibwezi was also significantly associated with placing of material underneath of maize during drying ($\chi2,1$ =7.759,P<0.001), cleaning of maize prior to storage($\chi2,1$ =13.938,P<0.001), mouldy condition of maize ($\chi2,1$ =4.117,P<0.05), perception that different maize affect aflatoxin occurrence ($\chi2,1$ =3.87,P<0.05), aflatoxin content in maize ($\chi2,1$ =3.98,P<0.05), proper maize storage ($\chi 2,1$ =6.014,P<0.02). In addition knowledge on health problems resulting from improper maize storage was significantly associated with knowledge on signs of aflatoxin in Kibwezi ($\chi 2,1$ =41.888,P<0.001), and in Kilome ($\chi 2,1$ =4.163,P<0.05).

DISCUSSION

Household socio-economic characteristics: Information on household socio-economic characteristics such age, sex/gender, education, occupation and income can have influence on adoption of maize storage practices and aflatoxin contamination of maize. In this study respondents who were mostly households' heads were mature adults with no significant disparity in their ages between the two study communities. There were more female respondents than male respondents in both study areas. This could be attributed to women being traditionally more concerned with household domestic roles compared to their male counterparts who have been more concerned with outdoor activities of seeking income for livelihood in order to sustain their families. This is consistent with Kenya 2009 census report which showed that females were more than males in the population in the ratio of 100:105(11). However, although there were more females than males in both study areas, there was no significant disparity in gender composition among the two study communities.

Majority of respondents in this study were married, but the difference between the two regions was small. Marriage as the primary family institution is crucial for management of family affairs at household level.Besides parents have responsibility of taking care of their children. They can also pool their resources and efforts together for the good upbringing of their children and ensuring they are healthy.

Regarding education level of respondents, majority had attained primary education which is considered to be basic level of education in Kenya. This implied that most respondents were sufficiently literate. The moderate literacy level could probably be attributed to free primary education policy of 2003 which increased access to education (12). It is recognized that education is crucial to understanding various concepts as well as their contextual application. Education is also important as it increases general knowledge and awareness and is believed to influence positive health behavior of a person and community in general.

On occupation of respondents, over three-quarters of respondents practiced small scale farming. The main crops farmed included maize, beans, cow peas and pigeon peas. Maize is a dietary staple food crop food in Makueni community, which is also staple food for about 90% of Kenya population (20). Other occupations were practiced by few respondents, implying that the two communities are predominantly agrarian. This small scale subsistence farming was also the main source of income for the majority of households. Thus it can be said that these communities derive their income mainly from farming which appeared to be the main occupation probably because the area is predominantly rural.

Income in a household is important for consideration since afaltoxin control and prevention interventions have cost implications. In this study majority of households were poor as they earned a monthly income of less than Kshs 5000, implying that they survived on less than a dollar per day. This is corroborated by Socio-economic Atlas Report of Kenya 2014 based on 2009 census which estimated poverty rate for Makueni County to be 60.6% (22). Thus this poverty rate was higher than the national poverty rate for 2009 of 45.2% (22). However there was a no significant disparity in mean income between high and low altitude areas indicating that the two communities were similar economically. The high level of poverty found in this study is consistent with other findings from government departments/agencies (7, 11) as well as Makueni County Demographic Profile (16). This finding is also consisted with the finding that the area is poverty stricken with majority of the people being absolute poor (7, 16). Agriculture is the main economic activity of the community and also the main source of income accounting for 78% (16). Drought is considered to be the main cause of poverty in the area as it reduces yields from farming. Maize is a staple food in the community and therefore its availability is an important indicator of food security.

Socio-economic Factors affecting Aflatoxin Contamination of Maize: This study has shown that certain socio-economic factors affect contamination of maize with aflatoxin. Sex or gender of respondent of household head was significantly associated with proper maize storage, in which proper maize storage was considered to be maize stored either in raised platform, granary, traditional cribs or improved cribs. This means that female headed households are more likely to store their maize properly than male headed households. This could be because women are traditionally more responsible for household chores and taking of family than men who are usually occupied with outdoor activities for income generation to sustain their families. Another factor was age of household respondent which was found to be significantly associated with knowledge/awareness of aflatoxin, and was also significantly associated with knowledge on signs of suspected aflatoxin contaminated maize. This association which was evident in both low and high altitude areas, implied that people of older ages were more likely to be aware of aflatoxin and also more likely to know signs of suspected aflatoxin contaminated maize and hence more likely to identify contaminated maize, than people of young ages.

There was also significant correlation/association between age of respondent and perception on whether altitude/climate affected aflatoxin contamination, implying that people of older age were more mythical and likely to consider altitude/climate to affect aflatoxin contamination than people of young age. In addition, level of education was significantly associated with knowledge/awareness of aflatoxin, implying that educated people were more likely to be aware of aflatoxin problem and its prevention than people with low or without education. That Level of education was also significantly associated with knowledge on signs of aflatoxin and identification of contaminated maize particularly in lower altitude areas meant that educated populace can easily identify maize suspected to be contaminated with aflatoxin than people with little or no education. This awareness level could be attributed to previous and ongoing aflatoxin awareness campaigns in the area following occurrences of episodes/outbreaks of aflatoxicosis (2).

In lower regions of Makueni, level of education was significantly associated with proper maize storage implying that people with education were more likely to store their maize properly than people without education. Level of education was also associated with discoloration of maize, pests' infestation of maize and cleaning of maize prior to storage. This association indicates that educated households are more likely to store their maize properly to avoid spoilage, insect infestation as well as maintaining their stores clean. Maintaining stores clean can greatly enhance prevention of insect infestation, mold growth and aflatoxin contamination of maize.

The occupation of household respondents who were house hold heads or their representatives was significantly associated with proper maize storage. This was an indication that knowledge and skills acquired in occupational trainings or people of particular occupations were more likely to understand and adopt proper maize storage practices in their households, than people without any occupational training or skills.

Results have demonstrated that income of household owner or household was significantly associated with knowledge/awareness on aflatoxin and was an indication that proper maize storage practices have cost implications which require finances for implementation. This shows that efforts to boost income of households will most likely have a profound impact on improvement of maize storage practices in the households.

Knowledge/awareness of Aflatoxin: Knowledge of a condition or situation can influence behavior change towards adoption and practice of an intervention. In this respect knowledge and awareness of aflatoxin is very crucial in its prevention. The level of awareness of aflatoxin was found to be substantially high in both areas as nearly everyone was aware of aflatoxin. This was consistent with previous study which found out that nearly 100% of farmers in Makueni were aware of aflatoxin (21). This could be attributed to sensitisation campaigns which had been conducted in the area following previous outbreaks of aflatoxicosis (2). It could also have been triggered by previous aflatoxicosis outbreaks which occurred in the area thus raising awareness and sensitisation on potential hazards of aflatoxin, a view supported by another previous study conducted (21) as well as by FGDs conducted .

Results further indicated that information on awareness was obtained from various sources, the main source of information in both areas being electronic media. This means electronic media was convenient and a preferred source dissemination of information. Previous study also found that media such as radio, TV, and newspapers were the key sources of aflatoxin awareness (21).

Knowledge on perception of health problems associated with improperly stored maize and not dried to moisture content level of less than 14% is important as it can give an indication on consequences related to consumption aflatoxin contamination and possibly trigger seriousness in undertaking preventive measures and hence enhance aflatoxin prevention. Equally important also is the knowledge in identification of contaminated maize as this can help early detection and sorting of bad maize from use as human food. Study also showed that most respondents were aware of problems associated with improper drying and storage of maize. This finding is supported by other previous studies which found that farmers were aware of health problems associated with aflatoxin contaminated maize (21). This underscores the impact of high level of awareness of aflatoxin in the community.

Another important aspect explored was on perception on causes of aflatoxin contamination of maize which is also crucial in determining aflatoxin prevention and control measures. In this study significant proportion of respondents cited improper drying of maize as the main cause of aflatoxin contamination, which was followed by improper maize storage. Although few respondents mentioned moldy/fungi as the cause of aflatoxin in higher regions, none of the respondents in lower region of Kibwezi directly attributed aflatoxin causation to mold/fungi infestation in maize. Early harvest and harvest of maize not properly dried was also mentioned by fewer respondents despite being potential contributor to causation of aflatoxin.

Household Respondents' perception on severity of aflatoxin problem was viewed as a pointer to the practice of its prevention and control. Thus knowledge of community perception on severity of aflatoxin problem could trigger prevention and control practices by the community. This perception on severity of aflatoxin problem was further underscored by the fact that besides causing illness and suffering, nearly half of respondents believed that aflatoxin was incurable/causes death. This was consistent with the views expressed during focus group discussions (FGDs) with community and in depth interviews with health workers, in which aflatoxin was considered to be the main serious health problem afflicting the community. Indeed aflatoxin poisoning can cause serious health effects to humans (14). Ingestion of higher doses (i.e. above 10ppb) of aflatoxin can result in acute aflatoxicosis, which manifests as hepatotoxicity or, in severe cases, fulminant liver failure, and chronic exposure causes underweight in children (5, 8).

Knowledge and awareness on various aspects of aflatoxin prevention is vital as well as a precursor to undertaking preventive and control measures such as proper maize harvesting, handling, drying and storage practices. Overwhelming majority cited proper drying and proper storage of maize after harvest as a way of preventing aflatoxin. This finding was also corroborated in FGDs, as well as in earlier study conducted (21). Harvesting of mature dry maize, though cited by few respondents, is one of the important ways of preventing mould growth and aflatoxin contamination. However, notably there were few respondents (about 5%) who did not know of any ways of preventing aflatoxin.

During aflatoxicosis outbreak of 2004 and thereafter there were rumors/beliefs from some community members that aflatoxin occurrence was attributed to by the "unfavorable" altitude/climate of the area. This study therefore collected views from respondents on their perception on whether different maize harvest seasons as well as different altitudes areas of maize growing with different temperatures and humidity do affect aflatoxin contamination of maize. About half of respondents' said altitude affected aflatoxin occurrence with higher areas having a higher proportion of respondents than lower areas who thought so. Conversely, the other half of respondents did not think altitude affected aflatoxin contamination. Moreover those who said altitude affected aflatoxin occurrence, overwhelming majority (over 90%) believed low altitude increased aflatoxin contamination of maize.

Further when respondents were asked whether different maize growing and harvest seasons affected aflatoxin contamination, about half of respondents' said different maize harvest seasons affected aflatoxin occurrence with more respondents in highlands than lowlands thinking so. Conversely, the other half respondents did not think different maize harvest seasons affected aflatoxin contamination of maize. Moreover those who said different maize harvest affected aflatoxin occurrence overwhelming majority (over 90%) believed aflatoxin contamination increased with the second maize harvest season of February/ March each year.

Aflatoxin Knowledge/Awareness factors affecting Aflatoxin Contamination of Maize: This study revealed that knowledge/awareness about aflatoxin problem was significantly associated with knowledge on signs of suspected contaminated maize thus indicating that knowledge is important in identification of maize suspected to be contaminated with aflatoxin. This knowledge could be useful in early identification and separation of contaminated maize, and hence remove it from human consumption. The suspected maize could then be taken for further testing to determine aflatoxin contamination. The removal of aflatoxin suspected maize from human consumption, could greatly reduce the risk of aflatoxin exposure to humans.

In addition the results showed existence of association of knowledge/awareness about aflatoxin problem with perception on health problems linked to consumption of aflatoxin contaminated maize could substantially boost awareness campaigns. Further knowledge/awareness about aflatoxin problem was associated with identification of contaminated maize implied that those who were aware of aflatoxin problem could easily identify maize suspected to be contaminated with aflatoxin. Besides awareness was associated with those whose maize was infested with by pests/insects while in storage, an indication that those who were awareness about aflatoxin are likely to take measures of preventing insect pest infestation.

The implication of this finding is that when people are aware of aflatoxin problem they consider it to be a seriousness issue, and hence they can undertake early identification of maize suspected to be contaminated and thus avoid its consumption. The study further had showed that knowledge/ awareness was positively correlated with removal of outer cover of maize cob during harvest, a key maize harvesting practice. This observed association indicates that increase in aflatoxin awareness is an important indicator in adoption of this positive practice in prevention of aflatoxin. Placing of maize during drying on top of impervious layer/material which is an important maize drying practice was also found to be significantly associated with knowledge/awareness of aflatoxin problem, hence further underscoring the importance of empowering people with knowledge. The practice of cleaning of maize prior to storage which is a crucial aspect of hygienic handling of maize was found to be associated with knowledge/awareness of aflatoxin problem, further underscoring the critical role of awareness in triggering adoption of positive practice.

Knowledge/awareness of aflatoxin problem was also associated with moldy condition of maize, implying that increasing awareness will likely improve proper drying and storage of maize and hence prevent/reduce moldy infestation. There was association between knowledge/awareness of aflatoxin problem and people who believe that different maize harvest seasons affect aflatoxin occurrence particularly the first maize harvest season which is usually done in February/March of each year. This view was also corroborated by focus group discussions conducted in the area and needs to be discouraged as it is not supported by scientific facts.

Moreover, knowledge/awareness of aflatoxin problem was associated with proper maize storage as well as the aflatoxin content found in maize, further underscoring the importance of enhancing awareness of aflatoxin prevention among the households.

Equally significant was that knowledge on health problems resulting from consumption of maize not properly stored was associated with knowing signs of maize suspected to be contaminated with aflatoxin. In view of this finding, educating communities on health problems linked to aflatoxin contaminated maize can greatly contribute in identifying and removing such maize.

Given that these factors were found to be associated with aflatoxin especially in low altitude areas where previous aflatoxicosis outbreaks had occurred, than in higher altitude area which had fewer aflatoxin outbreaks, is indication that the outbreaks had an impact on community sensitization and consequent adoption of aflatoxin prevention measures.

CONCLUSIONS

These study findings imply that efforts to control and prevent aflatoxin contamination of maize should take into consideration socio-economic characteristics as well as aflatoxin awareness. The results have further demonstrated that efforts to boost income and education levels of the community as well as raising aflatoxin awareness will most likely have a profound impact on improvement of maize storage practices in the households. There is need therefore for policy makers and stakeholders to promote socio-economic status of households as well as raising the level of aflatoxin awareness. As results have shown that female headed households are more likely to undertake proper storage practices for aflatoxin prevention, there is need for addressing gender parity in education, and economic empowerment of women. This can greatly enhance adoption and practice of aflatoxin preventive and control measures which could contribute to reduction of aflatoxin contamination of maize. An interventional study is needed to explore effects of household socio-economic factors and awareness on aflatoxin contamination of maize.

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