# Knowledge, Attitude and Practices (KAP) of Farmers on Postharvest Aflatoxin Contamination of Maize in Makueni and Baringo counties, Kenya

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## Abstract

Aflatoxin contaminated home grown maize has been a perennial problem in Kenya especially in the Eastern and North Rift parts of the country. This study focused on investigating the influence of knowledge, attitude and practices of farmers on aflatoxin contamination of maize in Makueni and Baringo counties in Kenya. A convergent mixed method study design combined quantitative and qualitative data collection techniques in maize producing areas of Baringo and Makueni Counties in Kenya. These methods included questionnaire administration, focus group discussions and key informant interviews. Of the 220 farmers who participated in the survey, 67.27% were male and 32.73% female in Baringo County whilst 45.45% male and 54.55% female in Makueni County. Majority of the farmers were in a marital union and were between the ages of 40-54 years. The average KAP score for knowledge was 57.6±11.79 % for both counties. The average knowledge score for Makueni was 37.70±11.36 % and 77.2±12.23 % for Baringo County. The average KAP attitude of the farmers in both counties was 77.1±9.32 %. There was a significant difference in the knowledge of factors contributing to aflatoxin in maize, as to the point where contamination begins, the signs of aflatoxin contamination and the consequences of aflatoxin exposure in both counties ($p<0.005$) The individual county scores were 76.5±9.24% and 77.7±9.41 % in Makueni and Baringo counties respectively. Socio-economic and demographic factors were linear predictors of knowledge ($R2=0.76$, $p<0.001$), whereas they had no effect ($R2=0.043$, $p=0.076$) on the attitude of the maize farmers. Farmers from Makueni County (Eastern Region of Kenya) were more likely (OR=1.24) to have higher knowledge scores on aflatoxin contamination than those from Baringo County (Rift Region of Kenya). On the contrary, with increasing age the maize farmers were less likely (OR=0.01) to have higher scores of knowledge. Farmers associated poorly dried maize and poor storage conditions as the maize cause of aflatoxin contamination. The study findings revealed a significant difference in knowledge and attitude between the two counties. This consequently had an effect on the practices of the farmers. There is need for increased awareness creation on dangers posed by consumption of

aflatoxin contaminated maize grain within the communities. Training of farmers on good agricultural and management practices is also of utmost importance. This coupled with regular surveillance and enhancement of laboratory capacities can also significantly reduce the occurrence of aflatoxicosis in Kenya.

Key words: Aflatoxin, maize, knowledge, attitude, practices

## 1. Introduction

The global production of maize is estimated to be 717 metric tons/year with United States, China and Brazil being the leading maize producing countries in the world with an estimated production of 563 metric tons/year *(Ranum et al., 2014*). It is also estimated that about 25% of this production is lost due to aflatoxin contamination *(WHO, 2018).* Maize is the most important food security crop in Kenya and plays a huge role in human nutrition with an estimated consumption of between 171g/person/day and 233g/person/day *(Ranum et al., 2014).* This data after extrapolation shows that a 60 kg adult on consumption of 233g of maize per day with a mean contamination of 17 ng/g (Arithmetic mean contamination of maize from four Agro-ecological Zones (AEZ) will translate to about 66 ng/kg of body weight *(Sirma et al., 2018).* Consumption of aflatoxin contaminated food in humans is associated with liver cancer, retarded growth and compromised immunity and aggravates infectious diseases such as tuberculosis, hepatitis and Human Immunodeficiency Syndrome (HIV)(EAC policy brief, 2018). Therefore, control of aflatoxin contamination in maize is of utmost importance. The control should be addressed both at the pre- and post- harvest levels. Understanding the farmers' perceptions, as the producer, is key to coming up with solutions. Several knowledge, attitude and practices (KAP) studies have been carried out in Kenya and Africa as a whole to document food safety scenario resulting from aflatoxin contamination *(Belayhun et al., 2019; Gichohi-Wainaina et al., 2020; Matumba et al., 2016; Udomkun et al., 2018).* In Congo for instance, farmers associated high levels of aflatoxin contamination to high humidity, improper storage practices and poor soils (Udomkun et al., 2018). This then led to discoloration of the grain and accompanied by unacceptable change in the organoleptic properties. This resulted in difficulty in selling the grain. In Ethiopia, majority of the respondents associated aflatoxin contamination to stomach related disorders, liver ailments including cancer *(Belayhun et al., 2019).* In Malawi, the farmers had relatively low knowledge scores on both pre- and post- harvest practices that lead to aflatoxin contamination *(Gichohi-Wainaina et al., 2020).* Higher knowledge scores were observed on issues related to income loss and less knowledge on the factors leading to occurrence of aflatoxins in produce. More educated households had higher knowledge scores as compared to those less educated. Pre- and post-harvest practices were recommended as a way of reducing cases of aflatoxin contamination in the produce. A similar study by Matumba et al. (2016) in Malawi, reported that about 33% of consumers bought mouldy maize despite the associated dangers of consuming aflatoxin contaminated foods. Aflatoxin contamination is a very perennial problem in Kenya as well with many reported cases that have resulted in many reported cases and even deaths *(Lewis et al., 2005; Sirma et al., 2018).* The objective of this study was to investigate the factors that influence the knowledge, attitude and practices of farmers on aflatoxin contamination in Makueni and Baringo counties in Kenya.

## Methods

### a) Study sites

The survey was carried out in Baringo and Makueni counties. Baringo County is located in the Rift Valley region of Kenya. It borders eight counties geographically. To the North are Turkana and Samburu Counties and Laikipia County to the East. It also borders Elgeyo Marakwet and Pokot Counties to the West, Nakuru and Kericho Counties to the South and finally, Uasin Gishu County to the South West. It covers 11,015.3Km2 of which 165km2 is surface water. Agriculture is the main economic activity in the county with 80% proportion . Baringo County consists of three major ecological zones: Highlands, mid and lowlands. The soils in the highlands are basically well drained and fertile making these areas suitable for agriculture and improved livestock development. The lowlands are semi-arid in nature with complex soils where essentially pockets of rain-fed subsistence agriculture is practiced and also under irrigation in some areas. On the other hand, Makueni County is located in the Eastern part of Kenya. It borders Machakos County to the North, Taita Taveta County to the South, Kitui County to the East and Kajiado County to the West. Most of the 8.034.7km2 is either arid or semi-arid *(Ranum et al., 2014)*. The main income generating activity in the county is agriculture. The long rains are received in April and May while the short rains in November and December *(Sirma et al., 2018)*. The county is exposed to serious climatic challenges that include drought, heat stress, moisture stress, increased precipitation and temperatures (20.2ºC -35.8ºC). Due to these challenges, food insecurity is prevalent. Aflatoxicosis has been a big challenge as well since the first major recorded case in the 2004 in the county which resulted in 317 cases and 125 deaths *(Sirma et al., 2018)*. Since then, the county has recorded several major and minor incidences. The survey targeted these new hot spots to unearth the underlying issues contributing to the aflatoxicosis cases. The study sites were purposively selected due to the higher occurrence of aflatoxin-related cases compared to the other counties in Kenya. The specific sub-counties were chosen based on the fact that these areas where mixed farming is carried out and maize growing is an important economic activity therefore likelihood of finding maize in such homesteads. The survey was carried out in Baringo North, Baringo South, Baringo Central and Eldama Ravine sub-counties in Baringo County (Fig 1). In Makueni, the sub counties sampled were Makueni and Mbooni (Fig 1) which had recently registered some mild cases of aflatoxicosis.

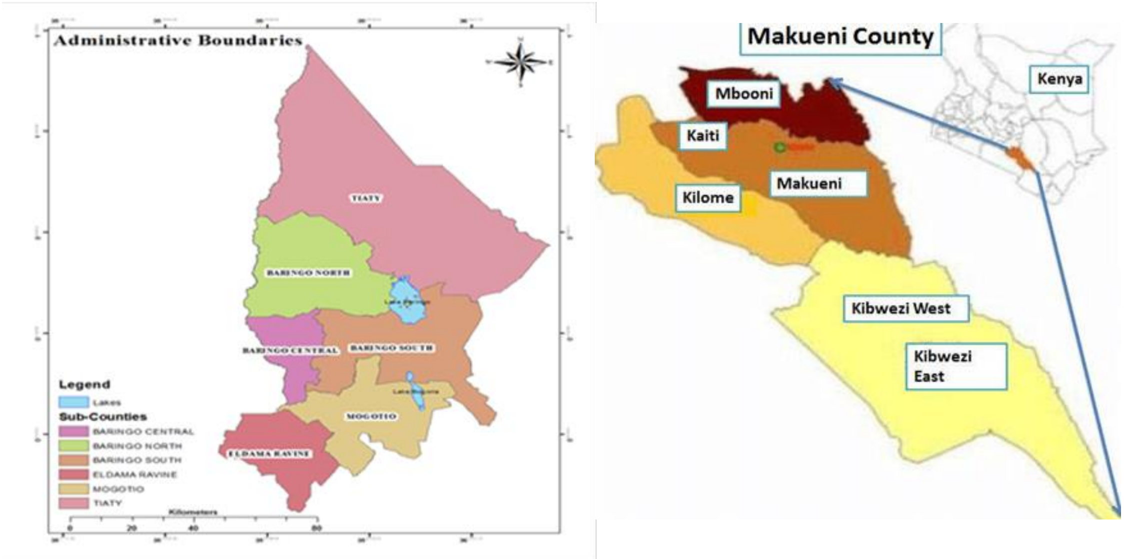


***Figure 1: Map of the study areas (Makueni and Baringo Counties, Kenya)***

**b) Determination of sample size**

The sample size was determined using the Fischer's formula (Fischer et al., 1991):

$$n = \frac{Z^2 pq}{d^2}$$

where n is the sample size, z is the normal deviation (1.96) corresponding to 95% confidence interval, p (0.5) is the estimated prevalence of aflatoxin in the county, q is 1-p and d is the degree of the desired accuracy (5%). This yielded a total of 196 households plus a 10% attrition giving a sample size of 216 households.

**c) Sampling procedure**

A mixed methods approach to data collection was used which included the use of semi-structured pre-tested questionnaires, focus group discussions and key informant interviews. Five enumerators in each county were selected and trained to aid in data collection. They were recruited based on their previous experience in similar research work and ability to understand and write in the local dialects, Kiswahili and English. Quantitative data was collected by administering a semi-structured questionnaire. A signed consent was sought from the farmers before the interview. A total of 220 questionnaires were randomly administered and shared equally between the two counties. The interviews were conducted in a combination of languages: local, Kiswahili and English. The semi-structured questionnaire was used to collect information on the farmer's demographics and knowledge, attitude and practices leading to aflatoxin contamination. A total of four focus group discussions were conducted with four farmer groups with each group consisting of 12 members divided equally between the two counties.

Key informants interviewed included senior ministry of agriculture officials, health officials and non-governmental organizations.

**d) Study tools**

The following study tools were used: A structured questionnaire, focus group discussion guide and key informant interview guide. Knowledge, attitude and practices were determined by questions in the questionnaire as follows:

i) **Knowledge**: It is the awareness of the community about aflatoxins. It was measured by calculating the mean score of 13 items and categorized as knowledgeable (if participants scored ≥ mean score of the correctly answered questions) or not knowledgeable (if participants score < mean score of the correctly answered questions).

ii) **Attitude**: The way a community thinks and behaves toward aflatoxin contaminated maize. It was measured by 13 questions with a five point like Likert's scale. All individual answers to attitudinal questions were computed to obtain total scores; then, mean score was calculated to categorize as having good attitude (if participants scored ≥ mean score) or poor attitude (if participants score < mean score).

iii) **Practice**: The behavior of a community that prevents or causes aflatoxin contamination. It was measured by 19 questions. All individual answers to practice questions were computed to obtain a total mean score and categorized as good practice (if participants scored ≥ mean score) or poor practice (if participants scored < mean score).

**e) Quality control**

Before administration of the questionnaire, farmers signed a consent form accepting to participate in the survey. The completed questionnaires were then checked for quality assurance before leaving the field.

**f) Ethical considerations**

Due to the corona virus pandemic, social distancing was maintained, masks and sanitizers were provided for all the study participants.

**g) Data analysis**

The data was then analysed using R software (version 4.0.3). A 5% level of significance was used throughout the study. Descriptive data on the socio-demographic and economic characteristics was generated. Moreover association tests to establish relationship of the socio-demographic on KAP scores was also undertaken.

## 2. Results and Discussion

### Socio-demographic characteristics of farmers

Of the farmers who participated in Baringo County, 67.27% were male and 32.73% female whilst in Makueni, the proportion of male and female respondents was 45.45% and 54.55% respectively. Those below the ages of 24 years were less than 2% in all the counties. Majority of the farmers were between the ages of 40-54 years and most were married, 82.73% and 81.82% in Makueni County and Baringo County, respectively (Table 1). Most of the farmers engaged in farming as well as business in both counties (Table 1). A small proportion was also in formal employment. Most of the farmers had inherited land on which they were farming with a proportion of 59.09% and 90% in Baringo and Makueni counties respectively. There was a similar trend in the sizes of land owned in both counties with majority owning 1-5 ha of land. This stood at 87.27% in Makueni and 81.82% in Baringo counties. A larger proportion of the farmers in both counties had a family size of between 1 and 5 family members. There was a significant difference in the gender, education, source of income, housing and land ownership between Makueni and Baringo counties.

**Table 1: Socio-demographic characteristics of farmers (N=220)**

| Farmer characteristics | Makueni (%) | Baringo (%) | p-value ($X^2$, df) |
|---|---|---|---|
| **Gender** | | | |
| Male | 45.45 | 67.27 | 0.002 (9.78,1) |
| Female | 54.55 | 32.73 | |
| **Age** | | | |
| ≤24 | 1.82 | 1.82 | 0.785(46.52, 55) |
| 25-39 | 28.18 | 33.64 | |
| 40-54 | 40.00 | 37.27 | |
| ≥55 | 30.00 | 27.27 | |
| **Marital status** | | | |
| Married | 82.73 | 81.82 | 0.466 (2.55, 3) |
| Separated | 0.91 | 1.82 | |
| Single | 6.36 | 2.73 | |

| | | | |
|---|---|---|---|
| Widowed | 10.00 | 13.64 | |
| **Education** | | | |
| Adult education | 1.82 | 1.82 | <0.001 (46.65, 6) |
| College/University | 14.55 | 37.27 | |
| Completed primary | 6.36 | 12.73 | |
| Completed secondary | 27.27 | 29.09 | |
| Dropped from primary | 12.73 | 3.64 | |
| Dropped from secondary | 36.36 | 7.27 | |
| Illiterate | 0.91 | 8.18 | |
| **Income source** | | | |
| Farming | 65.45 | 72.73 | 0.010 (13.37, 4) |
| Farming & Business | 32.73 | 19.09 | |
| Farming, Business & formal employment | 1.82 | 8.18 | |
| **Land ownership** | | | |
| Freehold title (inherited) | 90.00 | 59.09 | <0.001 (34.17, 6) |
| Freehold title (purchased) | 10.00 | 21.82 | |
| Community land | 0.00 | 8.18 | |
| Leased | 0.00 | 6.36 | |
| Rented | 0.00 | 4.55 | |
| **Farm size (ha)** | | | |
| ≤1 | 1.82 | 3.64 | 0.066 (35.15, 24) |
| 1 – 5 | 87.27 | 81.82 | |
| 6 – 10 | 8.18 | 13.64 | |
| ≥ 11 | 2.73 | 0.91 | |
| **Family size** | | | |
| 1 – 5 | 47.27 | 50.91 | 0.099 (22.36, 15) |

| | | | |
|---|---|---|---|
| 6 – 10 | 44.55 | 38.18 | |
| ≥ 11 | 8.18 | 10.91 | |
| **Housing (Floor/Wall/Roof)** | | | |
| Cemented/Iron sheets/Iron sheets | 32.73 | 0.00 | <0.001(101.41, 5) |
| Cemented/Stone/Iron sheets | 24.55 | 85.45 | |
| Cemented/Stone/Tiles | 2.73 | 2.73 | |
| Cemented/Timber/Iron sheets | 8.18 | 0.00 | |
| Earth/Mud/Iron Sheets | 17.27 | 0.00 | |
| Earth/Mud/Thatch | 14.55 | 11.82 | |

Similarly, there was a significant difference on the asset ownership of some assets between the two counties. These were the television and private wells. No farmer in Baringo County had a private well but 10.91% of farmers in Makueni County did. On the other hand more farmers in Baringo (65.45%) owned a television as compared to Makueni County (43.64%) (Table 2).

**Table 2: Asset ownership of maize farmers in Makueni and Baringo counties (N=220)**

| **Item** | **Baringo (%)** | **Makueni (%)** | **p-value ($X^2$, df)** |
|---|---|---|---|
| Motor vehicle (commercial) | 0.91 | 5.45 | 0.124 (2.36, 1) |
| Motor vehicle (Private) | 19.09 | 18.18 | 1 (0, 1) |
| Tuk tuk | 0.00 | 0.91 | 1 (0, 1) |
| Bicycle | 21.82 | 27.27 | 0.433 (0.61, 1) |
| Radio | 93.64 | 87.27 | 0.167 (1.90, 1) |
| TV | 65.45 | 43.64 | 0.002 (9.70, 1) |
| Mobile phone | 88.18 | 94.55 | 0.150 (2.07, 1) |
| Fixed phone | 1.82 | 0.91 | 1 (0, 1) |
| Generator | 12.73 | 7.27 | 0.261 (1.26, 1) |

| | | | |
|---|---|---|---|
| Well (Private) | 0.00 | 10.91 | 0.001 (10.67, 1) |
| Water pump | 6.36 | 8.18 | 0.795 (0.07, 1) |
| Bore hole | 2.73 | 8.18 | 1 (0, 1) |
| Water tanks | 55.45 | 52.73 | 0.787 (0.07, 1) |
| Livestock | 82.73 | 75.45 | 0.246 (1.35, 1) |

The most commonly accessed farm tool was the bull/donkey drawn plough which was highly significant with 84.55% and 14.55% in Makueni and Baringo counties respectively. The plough was mainly used for land preparation. Owning a wheel barrow was common in both counties. (Table 3)

**Table 3: Accessibility of farming tools among maize farmers in Makueni and Baringo counties (N=220)**

| **Item** | **Baringo (%)** | **Makueni (%)** | **p-value ($X^2$, df)** |
|---|---|---|---|
| Trailer (Tractor) | 1.82 | 0.91 | 1 (0, 1) |
| Harrow (Tractor) | 1.82 | 0.00 | 0.4775 (0.51, 1) |
| Plough (Tractor) | 7.27 | 7.27 | 1 (0, 1) |
| Trailer (bull/donkey) | 0.91 | 0.00 | 1 (0, 1) |
| Harrow (bull/donkey) | 0.91 | 2.73 | 0.6138 (0.25, 1) |
| Plough (bull/donkey) | 14.55 | 84.55 | <0.001 (105.03, 1) |
| Wheel barrow | 40.00 | 20.91 | 0.0034 (8.58, 1) |

**Knowledge assessment**

There was a significant difference in the knowledge of factors contributing to aflatoxin in maize, as to the point where contamination begins, the signs of aflatoxin contamination and the consequences of aflatoxin exposure in both counties ($p<0.05$) (Table 4). Makueni County had relatively higher frequency of farmers knowledgeable on aflatoxin contamination and the precipitating effects of such contamination.

**Table 4: Households' Knowledge about aflatoxin (N=220)**

| Parameter | Makueni | | | Baringo | | | p-value (X2, df) |
|---|---|---|---|---|---|---|---|
| | Yes (%) | No(%) | Don't Know (%) | Yes (%) | No (%) | Don't Know (%) | |
| **Causes of aflatoxin in maize:** | | | | | | | |
| Poorly dried or wet maize | 100 | 0.00 | 0.00 | 95.45 | 2.73 | 1.82 | 0.078 (5.12, 2) |
| Poor storage of maize | 95.45 | 4.55 | 0.00 | 36.36 | 61.82 | 1.82 | <0.001 (85.508, 2) |
| Drying maize on the ground | 63.64 | 36.66 | 0.00 | 6.36 | 91.82 | 1.82 | <0.001 (79.94. 2) |
| Shelling wet maize | 83.64 | 16.36 | 0.00 | 21.82 | 76.36 | 1.82 | <0.001 (84.57, 2) |
| **Contamination begins:** | | | | | | | |
| In the field when growing | 4.55 | 95.45 | 0.00 | 13.64 | 85.45 | 0.91 | 0.037 (6.61, 2) |
| During harvest | 91.82 | 8.18 | 0.00 | 27.27 | 71.82 | 0.91 | <0.001 (95.16, 2) |
| After harvest | 95.45 | 4.55 | 0.00 | 56.36 | 42.73 | 0.91 | <0.001 (45.99, 2) |
| In-storage | 94.55 | 5.45 | 0.00 | 9.09 | 90.00 | 0.91 | <0.001 (86.11, 2) |
| Improper drying | 91.82 | 8.18 | 0.00 | 30.91 | 68.18 | 0.91 | <0.001 (160.88, 2) |
| Not grading maize | 53.64 | 46.36 | 0.00 | 0.00 | 99.09 | 0.91 | <0.001 (81.03, 2) |
| Wet storage conditions | 70.91 | 29.09 | 0.00 | 1.82 | 92.27 | 0.91 | <0.001 (113.67, 2) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Signs of aflatoxin contamination:** | | | | | | | |
| Discolouration | 99.09 | 0.91 | 0.00 | 76.36 | 22.73 | 0.91 | <0.001 (26.39, 2) |
| Mouldiness and wetness | 98.18 | 1.82 | 0.00 | 38.18 | 60.91 | 0.91 | <0.001 (91.27, 2) |
| Presence of insects | 56.36 | 43.64 | 0.00 | 2.73 | 96.36 | 0.91 | <0.001 (76.40, 2) |
| Mouldy smell | 90.00 | 10.00 | 0.00 | 30.00 | 69.09 | 0.91 | <0.001 (82.56, 2) |
| **Aflatoxin exposure leads to:** | | | | | | | |
| Stunting in children | 49.09 | 50.91 | 0.00 | 1.82 | 96.36 | 1.82 | <0.001 (65.72, 2) |
| Immunity suppression | 76.36 | 23.64 | 0.00 | 17.27 | 80.91 | 1.82 | <0.001 (77.53, 2) |
| Low productivity in livestock | 71.82 | 28.18 | 0.00 | 8.18 | 90.00 | 1.82 | <0.001 (93.25, 2) |
| Liver cirrhosis (Liver cancer) | 73.64 | 26.36 | 0.00 | 23.64 | 74.55 | 1.82 | <0.001 (55.58, 2) |
| Loss of income | 57.27 | 42.73 | 0.00 | 86.36 | 11.82 | 1.82 | <0.001 (102.21, 2) |
| Death | 100.00 | 0.00 | 0.00 | 95.45 | 2.73 | 1.82 | <0.001 (27.75, 2) |

The average KAP score for knowledge of maize producing farmers in the two arid counties was 57.6±11.79 %. The average knowledge score for Makueni was 37.70±11.36 % and 77.2±12.23 % for Baringo County. At the sub-county level, there was a very significant difference in both counties. In Makueni County, Mbooni sub-county had a larger proportion of farmers with knowledge scores of between 26-50%, followed by Makueni sub-county (Figure 2).

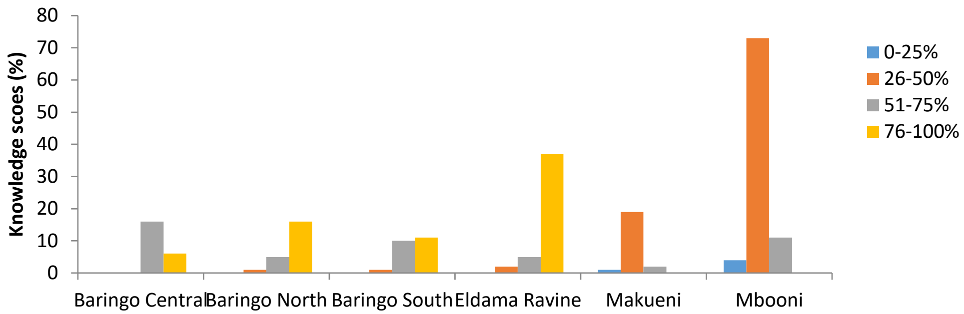


**Figure 2: Knowledge scores of farmers in Makueni and Baringo counties**

Wote (Makueni sub-county) can be considered a more peri-urban area as compared to Kisau Kiteta and Kako Woiya (Mbooni sub-county) which are remotely located. Outreach programs and projects by the Ministry and non-governmental organizations (NGO's) that train farmers on best practices mainly choose to work with farmers who are near the centres. This can explain the lower knowledge scores in Mbooni as compared to Makueni sub-county. Despite farmers in Baringo County having higher knowledge scores as compared to Makueni County, there was a variance at the sub-county level. Eldama Ravine sub-county had the highest number of farmers with between 76-100% knowledge scores. This can be explained by the fact that maize farming in Eldama Ravine sub-county is done is under large scale production and under irrigation.  There are over 30 irrigation schemes in Eldama Ravine under contract farming. Seed companies usually contract farmers and undertake very close monitoring and supervision of the crop to ensure high quality seeds are produced. Additionally, they also train farmers on the best practices which could have led to the huge variation compared to the other sub-counties in Baringo ($p<0.001$).

Socio-economic and demographic factors were linear predictors of knowledge ($R^2=0.76$, $p<0.001$) (Table 5). Farmers from Baringo County (Rift Region of Kenya) were more likely (OR=1.24) to have higher knowledge scores on aflatoxin contamination than those from Makueni County (Eastern region of Kenya). On the contrary, with increasing age the maize farmers were less likely (OR=0.01) to have higher scores of knowledge.

**Table 5: Linear model of predictor factors of knowledge scores of farmers on aflatoxin contamination of maize (N=220)**

| Variable category | Beta | Std error | P value | Odds ratios |
|---|---|---|---|---|
| (Intercept) | 0.63 | 1.79 | <0.001 | 1.88 |
| Gender Male | -0.18 | 0.07 | 0.726 | 0.84 |
| Age | -5.26 | 6.74 | 0.015 | 0.01 |
| Marital status Separated | -4.78 | 3.90 | 0.436 | 0.01 |
| Marital status Single | 1.84 | 2.82 | 0.221 | 6.32 |
| Marital status Widowed | -8.96 | 6.27 | 0.514 | 0.00 |
| Education College/University | -9.65 | 6.35 | 0.155 | 0.00 |
| Education Completed primary | -10.02 | 6.11 | 0.130 | 0.00 |
| Education Completed secondary | -12.66 | 6.45 | 0.102 | 0.00 |
| Education Dropped from primary | -11.79 | 6.09 | 0.051 | 0.00 |
| Education Dropped from secondary | -0.84 | 6.80 | 0.054 | 0.43 |
| Education Illiterate | 2.99 | 1.96 | 0.901 | 19.93 |
| Source of income Farming & Business | 2.24 | 4.46 | 0.128 | 9.36 |
| Source of income Farming & Employment | 1.11 | 11.77 | 0.616 | 3.04 |
| Source of income Farming, Business, Employed | 0.23 | 0.34 | 0.092 | 1.26 |
| Farm size | -37.78 | 1.81 | 0.491 | 0.00 |
| County Makueni | 0.21 | 0.32 | <0.001 | 1.24 |

| | | | | |
|---|---|---|---|---|
| Family size | 0.63 | 1.79 | 0.505 | 1.88 |

Adjusted $R^2$=0.760, p<0.001

**Attitude assessment**

The average KAP attitude of the farmers in both counties was 77.1±9.32 %. The individual county scores were 76.5±9.24% and 77.7±9.41 % in Makueni and Baringo counties respectively. Farmers in Mbooni sub-county had a better attitude on control of aflatoxin compared to Makueni sub-county. Eldama Ravine sub-county also had a higher proportion of farmers with a good attitude on control of aflatoxins compared to other sub-counties in Baringo County (Figure 3). The knowledge of the farmers on aflatoxin had a similar effect on his/her attitude with the exception of Makueni County (Figure 3). In Makueni, farmers with lower knowledge scores had a higher attitude scores which could be due to the high number of cases that have occurred in the county some of which have led to many fatalities (*Daniel et al., 2011; IFPRI, 2020; Lewis et al., 2005; Mwihia et al., 2008*). There was a significant difference in the attitude scores in both counties (p<0.003).

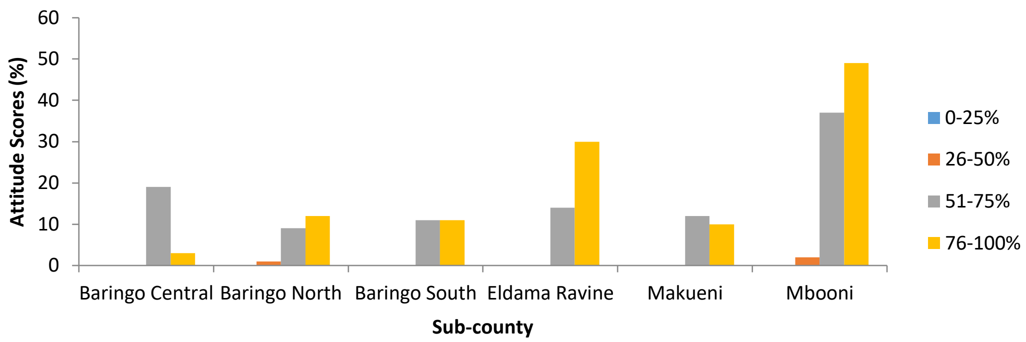


**Figure 3: Attitude scores of respondents in Makueni and Baringo counties**

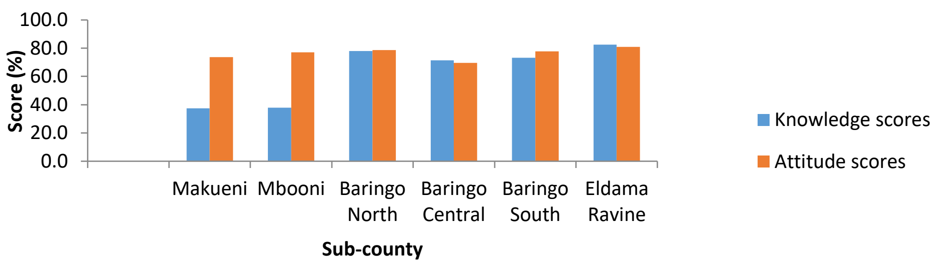


**Figure 4: Relationship between knowledge and attitude of farmers in Makueni and Baringo counties (N=220)**

Socio-economic and demographic factors had no effect on attitude of the maize farmers (R2=0.043, p=0.076) (Tables 6).

**Table 6: Linear model of predictor factors of attitude scores of farmers on aflatoxin contamination of maize (N=220)**

| Variable category | Beta | Std error | P value | Odds ratios |
|---|---|---|---|---|
| (Intercept) | 76.54 | 5.86 | <0.001 | <0.001 |
| Gender Male | 1.98 | 1.45 | 0.172 | 7.260 |
| Age | 0.00 | 0.06 | 0.943 | 1.000 |
| Marital status Separated | 1.24 | 5.44 | 0.821 | 3.440 |
| Marital status Single | -2.83 | 3.15 | 0.371 | 0.006 |
| Marital status Widowed | -0.04 | 2.28 | 0.986 | 0.961 |
| Education College/University | 2.13 | 5.07 | 0.675 | 8.370 |
| Education Completed primary | 3.59 | 5.13 | 0.484 | 36.40 |
| Education Completed secondary | 2.59 | 4.93 | 0.599 | 13.40 |
| Education Dropped from primary | 3.96 | 5.21 | 0.448 | 52.60 |
| Education Dropped from secondary | 2.29 | 4.92 | 0.641 | 9.920 |
| Education Illiterate | 6.12 | 5.49 | 0.267 | 456.00 |
| Source of income Farming & Business | -1.89 | 1.58 | 0.232 | 0.150 |
| Source of income Farming & Employment | 4.26 | 3.60 | 0.238 | 70.90 |
| Source of income Farming & Family support | 14.49 | 9.51 | 0.129 | >1000 |
| Source of income Farming, Business, Employed | 8.38 | 6.66 | 0.210 | >1000 |
| Farm size | -0.83 | 0.27 | 0.003 | 0.436 |
| County Makueni | 0.35 | 1.46 | 0.811 | 1.420 |
| Family size | -0.06 | 0.26 | 0.808 | 0.939 |

Adjusted $R^2$=0.043, p=0.076

**Practices assessment**

Harvesting was exclusively done manually by farmers in Makueni County and 95.45% in Baringo County. Manual use of labour in production of maize and use of artisanal tool were the most dominant practices (Table 7). Manual harvesting is not only labour intensive but also time consuming. However, over 80% of farmers in both counties had an average farm size of between 1-5ha, thus harvesting would not take such a long time. There was significant difference in the mode of handling, drying, shelling and storage of maize in both counties.

**Table 7: Summary of practices of respondents in Makueni and Baringo counties (N=220)**

| Practice | Baringo (%) | Makueni (%) | p-value ($X^2$, df) |
|---|---|---|---|
| **Mode of harvesting** | | | |
| Hand | 95.45 | 100.00 | 0.070 (3.27, 1) |
| Machine | 4.55 | 0.00 | |
| **Mode of handling** | | | |
| Maize stovers stacked in heaps | 3.64 | 27.27 | <0.001 (21.74, 1) |
| Maize cob removed while stovers standing | 96.36 | 72.73 | |
| **Drying** | | | |
| On ground with canvas | 51.82 | 39.09 | <0.001 (71.60, 10) |
| On ground without canvas | 28.18 | 60.91 | |
| Left to dry in field | 19.09 | 0.00 | |
| In an open store | 0.91 | 0.00 | |
| **Shelling** | | | |
| By hand | 13.64 | 49.09 | <0.001 (157.43, 11) |
| Use of machine | 81.82 | 10.91 | |
| Pounding manually in gunny bags | 4.55 | 40.00 | |
| **Storage** | | | |
| Gunny bags | 38.18 | 63.64 | 0.0003 (13.26, 1) |

| | | | |
|---|---|---|---|
| Pics bags | 51.82 | 40.00 | 0.105 (2.64, 1) |
| Granary/Thatch | 24.55 | 7.27 | 0.0009 (11.01, 1) |
| Granary/ Iron sheets | 30.91 | 31.82 | 0 (1, 1) |
| Air tight bins | 0.00 | 0.91 | 0 (1, 1) |
| Hermetic storage | 33.64 | 0.00 | 8.633 (42.11, 1) |
| **Mode of preservation** | | | |
| Insecticides (Actellic) | 82.73 | 76.36 | 0.251 (5.38, 4) |
| Ash | 0.00 | 4.55 | |
| None | 17.27 | 19.09 | |

**Focus group discussions**

The farmers had a wealth of knowledge on the different methods that were used to control aflatoxin in maize from time in memorial. Aflatoxin, also known as *'mbuuka'* in Kamba language in the Eastern part of Kenya was a term that was initially used to refer to maize that was not fit for human consumption. Due to discolouration, the maize, locally known as *'mbemba'* would be set aside as it had a bitter taste and would be fed to chicken. The farmers did not know that this was also poisonous but chose to set it aside due to organoleptic challenges. Farmers were also still using the traditional methods of preservation such as smoking and use of ash. Maize meant for seed or *'mbeu ya mbemba'* would be hung on the kitchen roof where it would be smoked gradually (Figure 5). This kept the maize intact free of insect attack as well as aflatoxin contamination until the next season.

Figure 5: Seed maize hung on ceiling of kitchen

Figure 6: Traditional thatch granary

Figure 7: Pics bags (hermetic bags)

Figure 8: Modern iron sheet roofed granary

Figure 9: Air tight bins (hermetic storage)

Figure 10: Aflatoxin contaminated maize/*'maozo'*

Maize meant for household consumption was on the other hand mixed with ash, also known as *'mouu'* and kept in the traditional granary (Figure 6), also known as *'ikumbi'* or *'ndaali'*. Modern methods are also used currently such as use of insecticides such as *actellic* to prevent insect attack especially weevils or *'ngulu'*. Maize in the *'keinga'* would dry fast within the store as they left spaces in between the walls to allow for free air flow. Farmers attributed the high cases of aflatoxin contamination to early harvesting, labour challenges due to too much work when airing the maize, poor onset of rains caused by climate change, ignorance of the communities on dangers of consuming contaminated maize, poverty, insecurity, interference by wildlife and differences in varieties. Maize is exposed to unfavourable conditions in the house due human and animal interference such as wild pigs also known as *'nguuwe'*. Farmers associated diseases to aflatoxin contamination in the community. These were linked to liver cancer, swelling of legs, joint pains and early child mortality. In children, farmers associate aflatoxin contamination with jaundice, also referred to as *'muuku'* which also clinically presents with vomiting and diarrhoea. It has also been associated with *'kwashiokor'* in children as children would be very skinny and swollen abdomen. Farmers were aware of the issue of bio-transfer of aflatoxin from contaminated chicken meat and even mothers milk. Maize stalks are usually left in the farm and start rotting when in the field. This contaminated feed is then fed to dairy cows and this ends up in the cow's milk. Their concern was that the community need more sensitization on the dangers of continued exposure to aflatoxin as a result of consumption of aflatoxin contaminated food and feed. Farmers suggested use of community health workers to educate the communities and also use of posters in schools, churches and health facilities.

The farmers have been advised by the ministry of agriculture to harvest and heap in the farm for 2-3 weeks to allow for complete drying. However, they still find it had to practice this due to seasonality challenges. Early onset of rains sometimes makes them harvest the maize prematurely and this has led to an influx of cases of aflatoxin contamination in maize. Attack by army worm attack and birds whilst still on the farm are also associated with contamination. Indigenous varieties locally known as *'kikamba'* or *'kinyanya'* were not susceptible to attack by fungi compared to the modern varieties. Hand harvesting is widely practiced while threshing is sometimes mechanized. The most common is use of gunny bags. Hermetic bags, which are locally referred to as *'kinga njaa'* are regarded as expensive and has challenges as they are not able to test the moisture content at the point of storage. If maize is not continually aired, this has led to cases of poisoning. Since most farmers are not able to afford a moisture meter, they have been taught by extension officers on how to use salt in a glass to assess whether the maize is adequately dried. Drying is done on tarpaulins (10%) and the other 90% of the population dries their maize on the ground due to lack of resources to buy and dependence on donations through outreach programs.

In Baringo County on the other hand, farmers had a wealth of traditional knowledge on preservation of maize. Similarly as in Makueni County, maize meant for seed *'sixtabut'or 'keswek'* was smoked in order to extend its shelflife till the next planting season. The maize which is locally referred by the Kalenjin community as *'bantek'* to as was hung on the central pillar/ *'tolkta* or *saina'* of the kitchen. The traditional store also known as *'choke'* is still widely used by farmers to store their maize. Ash is also added to the maize before storage to discourage attack by weevils and other insects. This is not widely practiced as compared to use of insecticides such as actellic. The farmers also feed contaminated grain to livestock as is the case in Makueni County.

**Key informant interviews**

Interviews with key informants in the county revealed many underlying issues. They pointed out that about two thirds of Baringo County receives erratic rains and cereals do not do well. Grains are thus imported from neighbouring counties such as Keiyo, Kericho, Bomet, Nandi, Nzoia,Trans Nzoia, Uasin Gishu and Nakuru. Maize from the neighbouring counties is often of very poor quality as they sell what has been rejected by National Cereals and Produce Board. Trucks lie in wait for buyers in markets under wet conditions at times due to erratic rains. Maize flour from these markets is bitter in taste due to aflatoxin contamination but is still widely consumed. Some of the markets include: Eldama Ravine, Mogotio, Kabarnet town, Barrwessa, Koloa, Chemalingot, Nginyang, Marigat, Mochongoi, Kabel, Kaptara, Kabartonjo and Kipsaraman. At Kaptara, there is barter trade of maize grain and livestock. Baringo county is also one of the tourist destinations due to some of its remarkable land and lake features such as Lake Bogoria, Lake Baringo, hot springs, flamingo's, lake 94 which is since sub-merged. There are many others. Maize is grown all across the six sub-counties; however, in large scale, this is in: Eldama Ravine, Baringo South – under irrigation and Mochongoi which is an island in Baringo South Sub-county. There are over 30 irrigation schemes in Baringo South under contract farming. These schemes are under the management of seed companies, who undertake very close monitoring and supervision of the crop to ensure high quality seeds are produced. Hence, aflatoxin is not such a big issue in these areas. However, this is a very serious issue for domestic subsistence farmers. The areas of concern are: Eldama Ravine, Marigat and Mochongoi. The current season was harvesting time for the lowlands where maize takes a very short time to grow as compared to the highlands. Maize in the low lands (Marigat) takes 3-4 months to mature whilst that in the highlands (Mochongoi) takes approximately 9 months to mature. Due to the climatic conditions, excessive heat in the lowlands hastens germination as compared to the highlands.

In Baringo County, the aflatoxin issue is very serious. This has been attributed to the rising cases of cancer in the county. This is due to lack of knowledge among the population. Maize is mainly consumed in form of *'ugali'* and fermented milk, commonly referred to as *'mursik'*. Another dangerous trend is the use of the rotten maize by farmers, locally known as '*maozo*' to make livestock feed or *'dairy meal'* .It is estimated to have approximately 90% aflatoxin and is bitter when used in cooked form or '*ugali'.* It is also used to prepare traditional fermented brews such as '*busaa* 'and '*chang'aa*' so when farmers get a lot of '*maozo*' after harvest they are usually very excited. Interestingly, in some cases, domestic animals like chicken, goats and cows refuse to consume it as it is unpalatable. Farmers often mill the '*maozo*' and mix with bran to improve its taste converting it to feed. There has been a lot of disconnect between government agencies such as the county agricultural extension officers and the public health department. This is because mothers are advised to consume whole grains which are often contaminated with aflatoxins. This in turn finds its way into the breast milk and this has been shown to cause serious side effects to the offspring. This include but not limited to reduced immunity, stunted growth, liver cancer and in more severe cases, death occurs.

Aflatoxicosis had been a big problem in Makueni County dating back to the year 2004 when some major cases were reported in Makindu and surrounding areas. Generally, whenever the area experienced long rainy seasons, they also experienced high levels of aflatoxin in maize. Since then, a number of development partners had come in to intervene and offer solutions. Some interventions have involved introduction of a strain to the soil to deter the growth of the Aspergillus strain. The carrier material used is sorghum which is broadcasted in the maize field during the growth stage. Other programs have been promoting postharvest practices among the farmers through various interventions: Farmers have often been encouraged to use tarpaulin to dry their maize and not on the soil as well as use of hermetic storage (bags/ containers). At times, the arrangement also includes cost sharing purchase of inputs – seeds, fertilizer, agro-chemicals, tarpaulin and hermetic bags. At the time of the survey, the current season activity was land preparation.

**Conclusions**

The average knowledge score is higher in Baringo County compared to Makueni County. This does not directly have an effect on the attitude and practices of the farmers. Despite the knowledge on the dangers associated with consumption of contaminated grain and the bio-transfer effect of aflatoxin such as to meat, poultry and even breast milk, some farmers still consume the maize. However, a large percentage of the farmers practice good agricultural practices such as drying maize adequately before storage, storing maize on a raised surface and even using hermetic bags to store the maize. Training of farmers on the good agricultural practices is therefore not enough to curb the recurrence of aflatoxicosis in these counties. It is imperative to also give recommendations on the methods that the farmers can use that are simple and affordable. Use of hermetic bags has been largely promoted in these counties but still remains a hurdle for most farmers due to affordability of the bags. There is also the challenge of ensuring the maize is at the right moisture content. Methods such as use of salt in a glass or bottle are simple and can be used by the farmers without difficulty. Farmers should also be encouraged to store their grain in aerated stores that are built on raised surfaces. Sensitization of farmers through community forums, posters in health centres and even schools can be useful in raising awareness on the dangers of consumption of contaminated grain.

**Recommendations**

Aflatoxin control and reduction in maize in Kenya requires a concerted effort by all the key players across the value chain. More importantly is to begin right from the production stage and this primarily revolves around the farmer. Hence, training of farmers on good agricultural and management practices is of utmost importance. There is need for increased awareness creation on dangers posed by consumption of aflatoxin contaminated maize grain within the communities. This coupled with regular surveillance and enhancement of laboratory capacities can also significantly reduce the occurrence of aflatoxicosis in Kenya.

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