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Millers on Hazard Analysis Critical Control Point (HACCP) for Aflatoxin Control in Maize; A Case in Kiambu County, Kenya.

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Abstract

Food safety management implementation is vital in food industries. Hazard Analysis Critical Control Points (HACCP) implementation in maize millers help in identifying aflatoxin hazards, prevent, reduce or eliminate them. Knowledge, attitude and practices (KAP) towards HACCP on aflatoxin determine the safety of the end product from its contamination. The main objective was to determine KAP on HACCP in Kiambu county maize millers in aflatoxin control. Clustering and systematic sampling methods were used to sample the 30 maize millers. 150 questionnaire respondents were selected randomly from the milling sub-sections. Multivariate probit model and multinomial logit model were used as the analytical framework for evaluating KAP. 60% of the respondents were male, 34% had completed university and 80% of the respondents from management section had completed university while dispatch section respondents had the lowest education level. HACCP average knowledge was 57.5%, 74.43% being highest from management section. HACCP attitude mean score was 3.326, management section showing more positivity with a mean of 3.633. Sufficient training and recruitment of food safety related experts across all sub- section would improve KAP towards aflatoxin reduction to the maize flour.

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Keywords
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HACCP;
KAP;
Maize Millers;
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Introduction

China, United States and Brazil are the leading maize producing countries globally with an estimated production of 563 metric tons/year.[1] 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 to 233g/person/day where it is estimated that about 25% of the total harvest is lost due to aflatoxin contamination.[2] The government of Kenya has been on a look out to the maize and maize products manufacturers on the issue of initiatives implementation to decrease the

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level of aflatoxin of the end products that is accessed in the markets. In Kenya, maize grains are a staple food consumed by members in the households and it's highly consumed by small -scale members.[3] They are consumed locally as flour, whole grain and *muthokoi*, as composite flour for porridge preparation and as a component of the animal feeds. It's used in the manufacturing of oil. Ready-to-Use Therapeutic Food (RUTF) has maize flour as the main ingredient for malnourished children feeding.[4] They have a risk of aflatoxin exposure to consumers when consumed when not properly sorted from moldy, shriveled, and damaged from insect and the kernels that are broken.[5] Aflatoxin is toxigenic, carcinogenic and mutagenic microorganism which lead to adverse health complications across the age groups who consumes the cereal based products. It's produced by *Aspergillus parasiticus* and *Aspergillus* flavus, found in humid and warm environment mostly affecting cereals which include nuts and maize grains. Maize, being the main staple food in Kenya and other countries in sub-Saharan African, its consumption is high and regular posing the risk of exposure to aflatoxins. Contamination can occur in the field during harvesting process and under storage facilities. However, post- harvest contamination is highly facilitated by the climate present during the harvesting time.[6] Drying on a bare soil lead to contamination after the harvesting process to the maize grains.[7] An incidence of 8% to 21% of maize in aflatoxin in Kenya was reported to be above the recommended the Food and Drug Administration (FDA) limits of 20 parts per billion.[8] Increased aflatoxin contamination was reported subsequently in food products and grains that were available in households and markets.[9] Health consequences and adverse nutrition effects were found after contaminated food were consumed.[10] Long-term aflatoxin exposure led to chronic health impacts which include cancer and stunting effects and acute exposure bring the aflatoxicosis or death effects.[11]

Trade can be negatively impacted upon grain contamination.[12] Maize millers can reduce aflatoxin contamination in the maize grains before milling and packaging by adopting appropriate practices such as timely use of chemical, physical and biological methods of decontamination.[13] Maize grains handlers in the milling plant' mitigations of contamination are achieved through proper sorting, elimination of shriveled and damaged kernels, aerated storage facilities, and also the use of hermetic bags.[14] Food safety management in a maize milling set up is well monitored by Hazard Analysis Critical Control Point (HACCP) principles incorporation which are guided by the maize millers' positive knowledge, appropriate attitude and practices (KAP) on aflatoxin contamination control. There is need for several training programs to maize handlers from the farm to the industries due to the reported aflatoxin contamination severity in Kenya.[15] The attitude in practicing aflatoxin mitigation approaches and the implementation is less studied in Kenya hence maize handlers KAP on aflatoxin is less practiced 16. Hence, there is need to assess the KAP of the maize millers so as to sensitize the millers, handlers and the consumers of the products on the level of integrity that is put on so as to ensure that there is safety in consuming maize and its products.

Methods

Study Site

Kiambu county has a land area of 2,417,735 square kilometers and borders Nairobi and Kajiado counties to the south, Machakos to the East, Murang'a to the North and North East, Nyandarua to the North West and Nakuru to the West as shown in figure 1. The county has a population of 1, 782,083.[17] The county has an average annual rainfall of 1,200 mm and a mean temperature of 26 ^{0}C. According to the 2019 census, there is a total population of 2,417,735 in the county: 1,187,146 males, 1,230,454 females, and 135 intersex persons with 796,241 households and the average household size of 3.0 persons per household and a population density of 952 people/ km^{2}.[18]

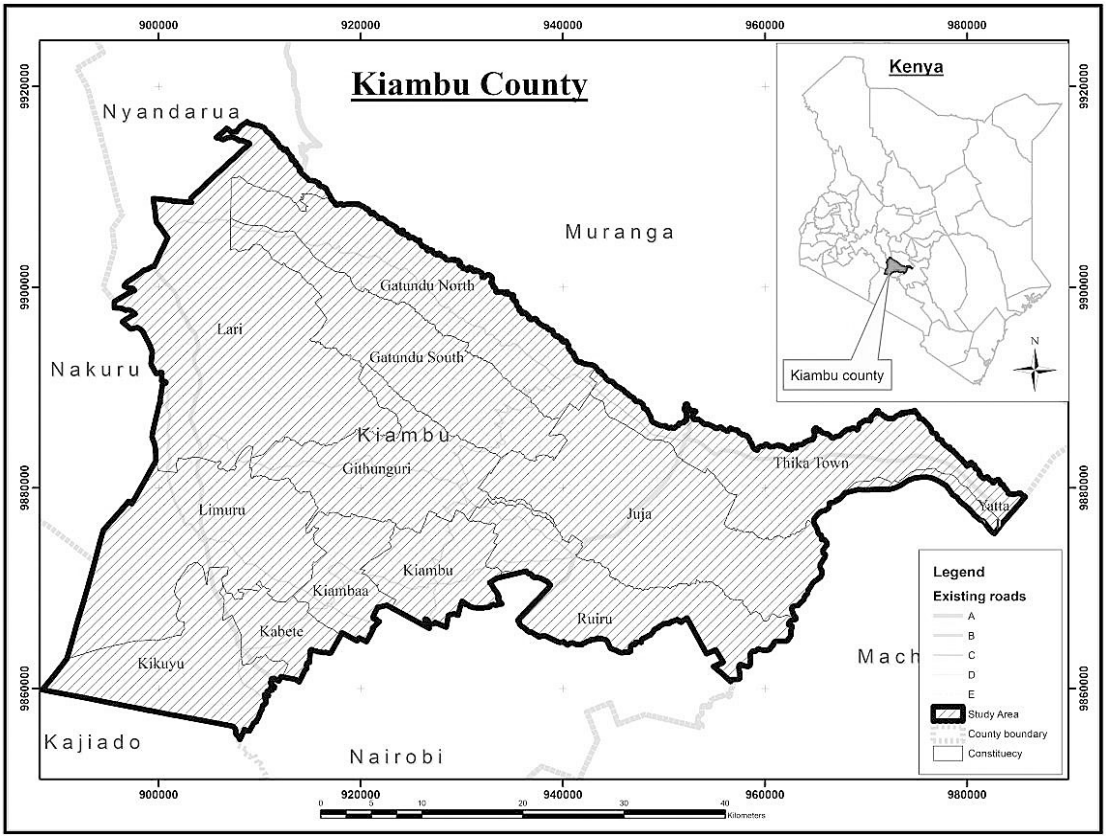

Fig. 1: Map of Kenya showing the location of Kiambu County

Source: 19: Key: Red: Location of Kiambu County

Determination of Sample Size

Kiambu County has 42 millers as per the Kenya Bureau of Standards to year 2022 which are distributed among the 12 sub-counties. The Yamane method,[20] was used with a 95% confidence interval and error level of 0.1 to calculate the minimum number of millers which were supposed to be used in the study.

$n_{Yamane} = N / (1 + Ne^2)$ where n was the number of sample size, N the size of the population and e, the allowed error.

Where $n_{Yamane}=42/ (1+42(0.1)^2)$
=30 maize millers

Study Design

The study design used was cross sectional. Assessment of the handling knowledge, attitude and practices on HACCP was done to the maize miller's management, raw material, milling, packaging and the dispatch sections to meet the standards of Food Safety Management System from ISO 22000:2018. The sampling of the individuals from the milling sub- sections was done through random method of sampling where they were interviewed from each sub- section.

Sampling Procedure

The clustering method was used to sample the millers depending on the ranking factors which included; Industry size, daily production and annual production then picked them using the systematic sampling method. The study population was the maize millers from Kiambu County. Data was collected by the use of the semi- structured questionnaire across all the sub- sections randomly from the sampled millers. The questionnaires containing the general

questions on knowledge, attitude and practices (KAP) and the social demographic characteristics were administered to the 150 respondents who were selected randomly from the milling sub- sections. There were some sub- counties that didn't have the maize milling plants and therefore they were not included in the study.

Study Tools

A semi- structured questionnaire was developed eliciting qualitative information mostly with open –ended questions. It was first tested through presenting it to a group of food safety researchers for the verification of its validity and reliability. Face-to-face interview was used to administer the questions with a selected individual from each sub-section of the milling set up. Different questions from the questionnaires were summarized using checklist that ensured the answers given were correct. Unique answers and different types of replies were determined. It was measured by categorizing the 14 items as knowledgeable or not knowledgeable. Attitude on HACCP by the handlers was also accessed where the thoughts and the behaviors towards the system on reducing the aflatoxin in maize was determined all the answers towards the aflatoxin attitude were measured by use of 12 questions. Five Likert's scale was used giving the scores and the degree of agreement or disagreement which include; Strongly disagree, Disagree, Neutral, Agree, strongly agree. The behaviors of the maize products handlers in the aim of reducing the aflatoxin content were accessed in terms of practices that are put into place which incorporates the HACCP system.

Quality Control

The questionnaire was first tested through presenting it to a group of food safety researchers for the verification of its validity and reliability. To ensure that the data collected was accurate, the interviewers were well informed on the key information they needed to collect data on and also the interviewees were well sensitized on the specific data that they were needed to give. If an interviewee gave incomplete data, they were required to interpret further so as to capture the right information even if it meant them to consult the supervisors in charge in the specific section of the milling system. The questionnaire was thoroughly proof led to ensure that it captured the only required information as per the objective and also to eliminate the duplication of the questions to enhance the data uniqueness. The already filled questionnaires were sealed completely to avoid the chances of misplacement or changing of the already given data.

Ethical Considerations

The respondents who were interviewed were sampled on voluntary bases, signed the consent form to show the acceptance to participate in the survey. The data provided by the millers were subjected to a high level of confidentiality and privacy. Only the data relevant to this study were collected from the millers. Since the maize millers' products' safety is monitored and regulated by the standard body, KEBS offered an authority letter as an access to the milling facilities.

Study Hypothesis

Kiambu county maize millers' socioeconomic variables were not significant linear predictors of HACCP knowledge, attitude and practices towards aflatoxin contamination in the maize and the products.

Data Analysis

This study adopted the use of a multivariate probit (MVP) and the multinomial logistic regression (MNL) models as the analytical framework for evaluating the food safety handling knowledge, attitude, and practices of maize and maize products millers. In this case, the MVP accounted for correlation as it modeled the effect of a set of covariates on the KAP responses while taking care of the correlated unobserved error terms. MVP was flexible to accommodate for the potential correlation of responses elicited from the knowledge, attitude, and practices on maize food safety handling. It's an extension of the bivariate probit which utilizes the Monte Carlo simulation techniques to jointly estimate the multiple probit equation systems.[21]

The MVP is explained in terms in the form of a correlated multivariate normal distribution that considers the underlying latent variables which are expressed as discrete variables through a threshold specification, and thus allows the flexible modeling of

the correlation structure and the simple interpretation of the observed parameters. Given that Knowledge (K), Attitude (A), and Practices (P) are a binary function of the decision makers and maize millers' characteristics, the MVP model is thus specified as below:

$$K=\beta^0_k+\beta_1^k X_1+\beta_{nk} Xn+\varepsilon^k, K=1 \text{ if } K>0,0 \text{ otherwise} \quad ...(1)$$

$$A=\beta^0_a+\beta_1^a X_1+\beta_n^a X_n+\varepsilon^a, K=1 \text{ if } K>0,0 \text{ otherwise} \quad ...(2)$$

$$P=\beta^0_a+\beta_1^a X_1+\beta_n^p Xn+\varepsilon^p, K=1 \text{ if } K>0,0 \text{ otherwise} \quad ...(3)$$

Where β is the vector parameters to be estimated, X is a vector of miller's characteristics, and ε is a vector of the error term. The error terms should thus follow a multivariate normal (MNV) distribution that depicts a zero conditional mean, with a variance normalized to unity,[22] (ε~MNV(0,Ω)), where Ω is the systemic covariance matrix which is defined as follows:

$$\Omega = \begin{bmatrix} 1 & \rho_{AK} & \rho_{MK} \\ \rho_{KA} & 1 & \rho_{MA} \\ \rho_{KP} & \rho_{AP} & 1 \end{bmatrix} \quad ...(4)$$

Where *p* is the unobserved correlation of the KAP equations. In the case that *p* was significant, it implied the interdependence between the error terms. A positive value of *p* was considered as promotive between the measured pair of equations, whereas, a negative value of *p* was substitutive. The variables that had an effect on the dependent variables (KAP), the three MVP regression equation analysis was fitted with a similar set of independent variables across the equations. These included socioeconomic and social demographic aspects such as duration of employment, age, year of education, gender and marital status, food science experts, were the hypothesized variables that influenced the knowledge, attitude, and practices on HACCP.

The research instrument was pre-tested to identify any problem with the content of the questionnaire including confusion with the overall meaning of the questions or misinterpretation of any term. This was done through administering to one maize milling company and based on the outcome of the pre-testing, modifications were made to the questionnaire.

Results

Socio- Demographic Characteristics of Maize Handlers in the Milling Firms

Overall, 150 respondents from milling firms in Kiambu County participated in the study. Majority 60% of the respondents were male with the raw material handling having the highest representation of males at 86.7% while the management section comprised of 63% males. The latter finding implies that at least one third of the management of the milling firms consisted of females. Most of the respondents (44.7%) had only completed secondary education while 34% had attended college or university. The management section had the highest number with college or university education (80%) while the dispatch section had the most respondents with primary school only level of education. The mean age of the respondents was 39.81 ± 8.784 years; the management section had the highest mean age at 42.93 ± 8.457 years while the dispatch section had the lowest mean age at 38.03 ± 8.331 years. Further, majority (78.7%) of the respondents were married with at least 70% of the respondents in every section indicating that they were married. Most of the respondents were employed on a part time basis (58%). Majority (76.7%) of the respondents who were employed full time were in the management section while the raw material handling and packaging sections had the lowest proportion of full-time employees each at 30%. Most of the respondents had worked in the milling firms for between 5 and 10 years (30.7%). The section with the most experienced workers was the packaging section where 33.3% of the respondent reported that they had worked for between 21 and 30 years. However, the management and milling section had the lowest number of respondents who had over 20 years' experience (6.7%). Finally, in terms of food security training, majority (84.7%) of the respondents indicated that they had received the FS training.

Knowledge of the Respondents

The average HACCP knowledge for the millers in Kiambu County was 57.5 ± 31.526%. HACCP knowledge was highest among the management section and lowest at the dispatch section as shown in the table 1. The binomial logistic regression model

Table 1: Maize products handlers' Knowledge on HACCP in mitigating Aflatoxin (N= 150)

	Management			Raw Material Section			Milling Section			Packaging Section			Dispatch Section		
	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know
HACCP KNOWLEDGE	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Have you ever heard of HACCP?	73	27	0	47	53	-	53	20	27	50	20	30	53	30	17
Do you know all the seven principles of the system?	63	37	0	20	80	-	10	83	7	0	77	23	7	87	7
Do you know the guid -elines followed in the application of the system?	50	30	20	17	83	-	23	73	3	0	73	27	7	90	3
Do you know where the systems should be applied?	47	30	23	30	50	20	47	47	7	17	63	20	3	87	10
Do you know which hazards are controlled using the system?	67	23	10	14	73	14	80	7	14	53	17	30	7	60	33
Is the system efficient in the controlling of the aflatoxins?	60	7	33	50	27	23	23	17	60	27	10	63	17	67	17
Failure to use the HACCP has no effect on the aflatoxin control	73	20	14	33	10	57	53	33	14	20	50	30	43	30	27
Hazard refers to any agent with potential to cause adverse health effect for consumers	93	0	7	90	3	7	100	-	-	77	20	3	53	10	37
Control measure means	83	3	14	83	0	17	73	23	3	20	27	7	57	20	23

was statistically significant at $p < .001$, X^2 (8) = 26.475. The model explained 47.6% (Nagelkerke R^2) of the variance in HACCP knowledge and correctly classified 93.3% of the cases.

	Management			Raw Material Section			Milling Section			Packaging Section			Dispatch Section		
	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know
HACCP KNOWLEDGE	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
setting in a method to protect aflatoxin from getting into a system															
Microbial testing is as good aflatoxin monitoring procedure	53	10	37	100	-	-	50	10	40	33	30	37	30	33	37
Chemical pesticides and fungicides in used in maize grain can lead to invasion of a contamination during processing	100	-	-	100	-	-	93	7	-	77	7	17	73	7	20
Proper cleaning of the maize grains reduces the number of physical hazards	100	-	-	100	-	-	70	3	27	100	-	-	93	3	3
Safety of maize flour is also determined by the cleanliness of the machinery along the milling chain	80	14	7	100	-	-	77	7	17	100	-	-	87	10	3
Storage techniques and handling of the final product has an impact on the quality and safety of it	100	-	-	70	-	30	90	-	10	100	-	-	83	10	7
Aggregate	74.43			61			60.14			48.14			43.79		
Standard Deviation (+/-)	18.161				33.142				26.982			35.482			31.232

Table 2: Linear model of socio-economic predictor factors of HACCP knowledge scores of millers (N=150)

Categorical Variable	B	S.E.	Wald	P-value	Odds Ratios
Constant	4.316	2.234	3.731	0.053	74.855
Gender	-0.098	0.602	0.027	0.871	0.907
Education level	0.972	0.476	4.168	0.041	2.643
Age in Years	-0.014	0.032	0.199	0.656	0.986
Marital status	-0.137	0.295	0.216	0.642	0.872
Employment status	1.247	0.673	3.431	0.064	3.48
Length of Service	-1.701	0.441	14.869	0.000	0.183
Work Section	-0.107	0.219	0.24	0.624	0.898

Adjusted R^2 = .476, $p \leq 0.05$

Attitude Assessment

The aggregate mean score for HACCP attitude among the millers was 3.326 as per the Likert scale and a standard deviation of 1.0894 as shown in table 3. Multinomial logistic regression was used to assess the HACCP attitude along the socioeconomic and food safety training variables among the millers. The regression model significantly fit all the variables at $p < .001$ and explained 68.7% (Nagelkerke R^2) of the variance in HACCP attitudes.

Table 3: Maize products handlers' attitude on HACCP towards aflatoxin mitigation

General HACCP attitude	Management	Raw material section	Milling section	Packaging section	Dispatch section
	Mean	Mean	Mean	Mean	Mean
The principle of HACCP system is to prevent aflatoxins in the stages before the endpoint of production	4.17 ±0.592	3.7 ±0.75	3.67 ±0.758	3.9 ±0.96	3.9 ±1.348
According to prerequisite programs it is enough to clean the milling system only before starting	3.5 ±0.974	3.07 ±0.868	3.2 ±1.297	3.23 ±1.251	3.57 ±1.104
HACCP is an obligatory system that all food related plants should	3.13 ±0.973	3.5 ±0.82	3.4 ±1.163	3.03 ±1.033	2.9 ±0.995
apply HACCP is not a very effective system to provide food safety	3.5 ±0.777	3.13 ±0.973	2.83 ±1.234	3.23 ±1.104	2.87 ±1.042
HACCP is a mandatory system in Kenyan food law	3.4 ±0.77	3.07 ±1.112	3.07 ±1.048	3.33 ±1.213	2.97 ±1.098
Each hazard that may reflect to end product should be identified and	3.53 ±0.776	3.4 ±0.968	3.1 ±1.094	3.53 ±1.57	3.2 ±1.648

recorded according to HACCP principles					
HACCP is a food safety law specific to our country	3.53 ±0.776	3.2 ±0.997	2.8 ±1.095	3.1 ±1.296	3.07 ±1.507
Prerequisite programs that include all hygiene rules must be fulfilled prior to the implem-entation of the HACCP system	3.73 ±0.828	3.07 ±1.048	3.03 ±1.033	3.63 ±1.45	3.27 ±1.552
The HACCP system requires staff training in hygiene	3.53 ±0.9	3.63 ±0.964	3.37 ±1.098	3.63 ±1.066	2.37 ±1.033
Prerequisite programs are accepted as infr-astructureof any food business	3.6 ±0.724	3.47 ±1.042	2.9 ±1.125	3.17 ±1.44	3.23 ±1.547
Microbiological hazards cannot be included in HACCP	3.6 ±0.621	3.3 ±1.208	3.27 ±1.437	3.23 ±1.165	3.1 ±1.094
It is essential to keep track of and to record every step of food production in HACCP system	4.37 ±0.718	3.77 ±1.431	3.23 ±1.135	3.3 ±1.343	3.03 ±1.377
Aggregate	3.633 ±0.786	3.359 ±1.015	3.156 ±1.126	3.359 ±1.241	3.123 ±1.279

The regression model was significant at P< .001

Table 4, shows the linear model of socio- economic predictor factors of HACCP attitude scores towards aflatoxin reduction in maize flour from millers in Kiambu County.

Table 4: Linear model of socioeconomic predictor factors of HACCP attitude scores of millers (N=150)

Categorical Variable	B	S.E.	Wald	P-value	Odds Ratios
Constant	-1.038	3.773	0.076	0.783	
Gender	1.525	1.555	0.962	0.327	4.597
Education level	0.133	1.809	0.005	0.942	1.142
Age in Years	0.093	0.089	1.085	0.298	1.097
Marital status	1.196	2.679	0.199	0.655	3.305
Employment status	-2.706	1.685	2.581	0.108	0.067
Length of Service [<5 years]	16.38	1.221	179.928	0.000	357.48
Work Section [milling section]	19.301	1.754	121.116	0.000	702.7
Food Safety Training [No]	-3.292	1.620	4.129	0.042	0.037

Assessment of Practices of Aflatoxin Accumulation

The study also examined the practices related to aflatoxin accumulations across the various sections in the milling firms. The findings are summarized in Table 5.

Table 5: Practices of Aflatoxin Accumulation

Section	Practices related to Aflatoxin Accumulations				
		Yes	**%**	**No**	**%**
Management	Employment of food safety and related field experts	17	57%	13	43%
	Training the employees on Food safety frequently	9	30%	21	70%
	Incorporation of HACCP in maize flour production	5	17%	25	83%
	Buying of moisture and Aflatoxin testing machines	11	37%	19	63%
	Ensuring a track record of maize flour batches sold out	10	33%	20	67%
	Fully installation of prerequisite programs in the firm	7	23%	23	77%
	Sub -contracting analysis of aflatoxin	7	23%	23	77%
	Aggregate	**31.4%**		**68.6%**	
Raw material section	Analysis of aflatoxin	17	57%	13	43%
	Analysis of moisture content	20	67%	10	33%
	Drying on a mat	17	57%	13	43%
	Manual sorting	24	80%	6	20%
	Electric sorting	3	10%	27	90%
	UV sorting	3	10%	27	90%
	Sun drying	23	77%	7	23%
	Electric drying	7	23%	23	77%
	Sisal Bags	20	67%	10	33%
	Airtight Bins	10	33%	20	67%
	Hermetic Bins	30	100%	0	0%
	Insecticides	14	47%	16	53%
	None	15	50%	15	50%
	Aggregate	**52.1%**		**47.9%**	
Milling section	Verification of cleaning of the maize grains	9	30%	21	70%
	Verification of cleanliness of the milling system	6	20%	24	80%
	Cross contamination assessment	5	17%	25	83%
	Aggregate	**22.2%**		**77.8%**	
Packaging section	Automated packaging	4	13%	26	87%
	Use of stainless-steel scoping materials	20	67%	10	33%
	Use of stainless- steel storage bin	26	87%	4	13%
	Use of a different room for packaging	7	23%	23	77%
	Storage of the packaged flour in a cool dry place	12	40%	18	60%
	Storage on ranks	15	50%	15	50%
	Stored in aerated rooms	12	40%	18	60%
	Aggregate	**45.7%**		**54.3%**	
Dispatch section	Keeping records of the dispatched batches	18	60%	12	40%
	Use of no hooks during loading	27	90%	3	10%
	Closing of the loaded trucks to avoid rains penetration	27	90%	3	10%
	Aggregate	**80.0%**		**20.0%**	

Relationships between HACCP Knowledge, Attitudes and Aflatoxin Accumulations Control

Following these findings, there was also need to establish whether HACCP knowledge and attitudes on HACCP system on food safety significantly contributed to the practices related to aflatoxin accumulations control where multiple regressions were carried out HACCP knowledge

and HACCP attitudes as the independent variables, the aflatoxin accumulations control practices as the dependent variable where $p \leq 0.05$. The findings are summarized in Table 6.

Table 6: HACCP Knowledge and Attitudes on Practices of Aflatoxin Accumulation

Section	Practice	HACCP knowledge		HACCP Attitude	
		Chi-Square		Chi-Square	
		Value	P-value	Value	P-value
Management	Employment of food safety and related field experts	4.588	0.032	5.635	0.228
	Training the employees on Food safety frequently	2.571	0.109	3.593	0.464
	Incorporation of HACCP in maize flour production	30.000	0.000	5.905	0.206
	Buying of moisture and Aflatoxin testing machines	10.364	0.001	4.456	0.348
	Ensuring a track record of maize flour batches sold out	3.000	0.083	3.077	0.545
	Fully installation of prerequisite programs in the firm	19.714	0.000	4.082	0.395
	Sub -contracting analysis of aflatoxin	1.826	0.177	1.033	0.905
Raw material section	Analysis of aflatoxin	.084	0.773	6.656	0.155
	Analysis of moisture content	.577	0.448	7.259	0.123
	Drying on a mat	.084	0.773	6.656	0.155
	Manual sorting	.072	0.788	5.223	0.265
	Electric sorting	.513	0.474	2.619	0.623
	Uv sorting	.513	0.474	7.778	0.100
	Sun drying	1.405	0.236	7.839	0.098
	Electric drying	1.405	0.236	7.839	0.098
	Sisal Bags	2.308	0.129	5.330	0.255
	Airtight Bins	2.308	0.129	5.330	0.255
	Hermetic Bins	-	-	-	-
	Insecticides	5.275	0.022	3.023	0.554
	None	4.615	0.032	2.286	0.683
Milling section	Verification of cleaning of the maize grains	2.571	0.109	16.813	0.001
	Verification of cleanliness of the milling system	13.500	0.000	15.302	0.002
	Cross contamination assessment	1.200	0.273	4.062	0.255
Packaging section	Automated packaging	5.370	0.020	30.000	0.000
	Use of stainless- steel scoping materials	3.606	0.058	19.200	0.001
	Use of stainless- steel storage bin	.710	0.399	7.972	0.047
	Use of a different room for packaging	1.405	0.236	15.771	0.001
	Storage of the packaged flour in a cool dry place	.192	0.661	23.125	0.000
	Storage on ranks	1.154	0.283	13.855	0.003
	Stored in aerated rooms	.433	0.511	9.034	0.029
Dispatch section	Keeping records of the dispatched batches	1.000	0.317	10.816	0.029
	Use of no hooks during loading	.667	0.414	13.333	0.010
	Closer of the loaded trucks to avoid rains penetration	16.667	0.000	30.000	0.000

The aflatoxin control practices model with the milling sub- sections as the dependent variables, HACCP knowledge and HACCP attitudes as the independent variables were significant at p< 0.001 with the management section practices, p= 0.000 packaging section practices and p= 0.007 with dispatch section practices models adjusted to their respective R-Square (R^2) and percentage variations as shown in table 7.

Table 7: Regressions of HACCP knowledge and attitudes on aflatoxin control practices

Aflatoxin Control Practices		R	R Square	Adjusted R Square	F	(Constant)	HACCP Know -ledge	HACCP Attitude
							Beta	Beta
Management	Value	.646b	0.417	0.374	9.649	12.957	2.167	0.062
	Sig.				.001c	0.000	0.000	0.799
Raw material handling	Value	.311b	0.097	0.029	1.443	19.245	0.573	0.219
	Sig.				.254c	0.000	-0.175	0.289
Milling	Value	.341b	0.116	0.051	1.778	3.76	-0.36	0.322
	Sig.				.188c	0.000	0.200	0.079
Packaging	Value	.716b	0.512	0.476	14.163	8.3	0.306	0.411
	Sig.				0.000	0.000	0.226	0.000
Dispatch	Value	.557b	0.31	0.259	6.068	6.513	-0.113	-0.316
	Sig.				.007c	0.000	0.666	0.002

Discussions

In Kiambu county maize milling firms, majority of the respondents were found to be men across all sections. In the raw material section, it was found to demand a lot of man power due to the majority assignment being manual which included the transport of the maize grains' sacks in and out of the storage facilities. For quality delivery during the milling process, incorporation of male gender was part of conceptual framework development in this section. The number of the study participants with food science related education level was low therefore, it is believed that the milling process of the maize flour may have limited cautions during HACCP implementation due to insufficient knowledge. In total, only 34% of the respondents attained the university education compared to a study report that showed the respondents who attended the university were 50.5 %,[23] majority of them coming from the management section therefore they had the knowhow in exercising their mandate of leading and improving the product handling team to install the aflatoxins reduction measures through HACCP installation which was found to be relatively low in this study.[24] Work experience in the maize milling firm is gained while working in a similar set up for a prolonged period of time enough to gain sufficient technics and capacity particular on the food safety system backed up by the food science related course studied in the university. According to a study that was conducted elsewhere, showed that the level of the prolonged work experience has a significance correlation with the total KAP scores on food safety handling technics[25] where in this study, handlers from the packaging section were the most experienced team probably because the packaging assignment didn't require any technical knowledge unless it was done electrically a method that was not embraced by many millers in the county.

The number of permanent employees in the maize milling firms in Kiambu County was high in management section probably because they owned the plants. As part of achieving the production of the maize flour which is free from aflatoxin, training on Food safety management systems as they are

outlined in ISO 22000 to the maize and the maize flour handlers is important. By doing so, they get the clear interpretation on the relevant knowledge needed in handling, positive attitude towards the implementation of HACCP and proper gear to install the practices of aflatoxin levels reduction along the milling chain. In this study, a sufficient number of the handlers showed to have acquired the food safety training but with a disadvantage of unevenly training across all the subsection. A similar study showed a more positive number of the same which demonstrated that its attainable showing a positive association towards food safety[26] and therefore, the raw materials handling and packaging sections had the most respondents trained at 86.7% probably due to low cost of training in these sections. Un availability of food safety trained manpower has found to be a great challenge in many food industries where they only follow the directives of their supervisors but generally, they have low education level and hence training is required to be impacted to them to incorporate the HACCP principles.[27]

HACCP installation knowledge is found to be enhanced through consecutive trainings. A study was conducted and showed the mean knowledge score being 77% which was higher than the one obtained from this study which was said to have been facilitated by increased training sessions on HACCP implementation,[28] Kiambu county maize millers' survey findings revealed that socioeconomic variables were significant linear predictors of HACCP knowledge where the education level was associated with increased HACCP knowledge as another study confirmed.[29] Also in every food industry, knowledge has shown to impact positively on the attitude towards hazards levels in the products.[30] Most of the millers in Kiambu County were inclined to agree with the requirements of HACCP. However, the management members had more positive attitude towards HACCP than all their counterparts with those working in the dispatch section showing the least favorable attitude towards HACCP. Most millers agreed that the principle of HACCP system was to prevent the hazards in the stages before the endpoint of production as indicated by the highest favorable ratings across all sections. However, they tended to disagree that HACCP is a mandatory system in Kenyan food law. With this notion, this may be the reason why their attitude towards HACCP installation in the maize milling firms with the aim of reducing aflatoxin is poor. A different study showed the satisfactorily and a positive level of attitude of the food handlers toward HACCP compared to the results of this study.[31] Also, a proper approach to aflatoxin management by the management members has shown to yield a positive attitude too from the employees which is not emphasized by the Kiambu maize millers.[32]

The findings of the socio-economic predictor factors of HACCP attitude linear model revealed that socioeconomic variables, Length of Service, Work Section and Food Safety Training were significant linear predictors of HACCP attitude among the maize handlers. This shows that millers with less than 5 years length of service and especially those working in the milling section were inclined to have a favorable attitude towards HACCP. It also emerged from the findings that millers who did not have food safety training had a negative attitude towards HACCP system underscoring the need for further training for the millers.

It is evident that in the management and raw material handling sections, HACCP knowledge rather than attitudes informed the practices related to aflatoxin accumulations control where in contrast, HACCP attitudes rather than knowledge influenced the practices related to aflatoxin accumulations control in the milling, packaging and dispatch sections significantly at $p \leq 0.05$ according to HACCP knowledge, attitude and practices of aflatoxin reduction relationship analysis. This partly explains why despite the relatively low HACCP knowledge scores in the packaging and dispatch sections, practices related to aflatoxin accumulations control were well adhered to in the sections.

The findings also show that HACCP attitudes contributed more to aflatoxin control practices than HACCP knowledge and this could explain why the milling section had the lowest adherence to aflatoxin accumulations practices. Therefore, it is evident that more HACCP knowledge could significantly improve aflatoxin control practices. Further, inculcating the right attitudes on HACCP to the millers in all sections could significantly help to improve aflatoxin reduction practices.

During the regression analysis of HACCP knowledge, attitude and aflatoxin reduction practices, only HACCP knowledge at p = 0.000 was the significant independent variable in the model suggesting that the management practices for aflatoxin control could increase by 2.167 units when the HACCP knowledge increased by one unit. The aflatoxin control practices model with packaging practices as the dependent variable and HACCP knowledge and HACCP attitudes as the independent variables was also significant at p = 0.000 where the model could explain up to 47.6% of the variations in the packaging practices for aflatoxin control. However, only HACCP attitude was the significant independent variable in the model implying a unit change in HACCP attitude would result in an increase of 0.411 units in the packaging practices for aflatoxin control. The aflatoxin control practices model with dispatch practices as the dependent variable and HACCP knowledge and HACCP attitudes as the independent variables was significant at p = 0.007. However, only HACCP attitude was a significant independent variable at p = 0.002 and had an inverse relationship with the dependent variable in the model suggesting that the dispatch practices for aflatoxin control could decrease when the HACCP attitude increased by one unit. Therefore, a negative or poor attitude on HACCP could adversely affect the packaging practices for aflatoxin control. The study, however, failed to predict linear models for raw material handling practices and milling practices in aflatoxin control. Raw maize handling, is one of the initial stages that require proper HACCP incorporation in a maize milling chain with the effort of aflatoxin reduction. This involve the post- harvest practices required to reduce aflatoxins in the maize flour produced and has been found effective[33] which includes sorting, drying and protecting maize grains against insect infestation.[34] Hand sorting has proven to be an effective way of reduction non wholesome maize grains.[35] Grains drying is a critical factor for maintaining low aflatoxin levels in produced maize flour worldwide.[36] Likewise, majority of the maize handlers in Kiambu County has shown to adhere to these practices effectively. Keeping the records of the quality of the dispatched maize flour that may contain aflatoxin levels beyond the thresholds to the consumers is a crucial step that enable monitoring, installation of recalling measures, decontamination or destruction of the product.[37] Also, it has shown to lead to improved aflatoxin forecasting models through knowing of the contamination in advance with an aim of protecting the health risks and economic losses.[38] Kiambu county maize millers have shown a relatively enlighten about the installation of these practices.

A study was conducted on the estimation of KAP to personnel who indicated that about 58% of them even didn't know the adoption of HACCP in a food industry set up was important[39] but the maize handlers in Kiambu County showed to rise to an aggregate value of about 52% which is relative apart from the un uniform nature of its adoption across all milling sections which should be enhanced by the management section. Due to none fulltime monitoring effect, milling section showed poor adherence to practices of aflatoxin reduction which include the cross -contamination assessment within the time of milling and poor cleaning activities of the various systems of milling sections which include the cutters, de -germer and the milling rollers where studies have shown aflatoxin cross contamination.[40]

Conclusions

According to the findings of this study, all the maize millers in Kiambu County require closer observation of the levels of Quality management systems instalment accessed so as to acquire the comprehensive information on the KAP of the millers within the stipulated time intervals of the validity of the permit of operation from Kenya Bureau of Standards (KEBS).

Overall, the study concludes that the practices related to aflatoxin accumulations were not well emphasized in the milling firms. HACCP attitudes rather than knowledge largely informed the practices related to aflatoxin accumulations control. Therefore, inculcating the right attitudes on HACCP to the millers in all sections could significantly help to improve aflatoxin accumulations practices.

Assessment of knowledge, attitude and practices of the maize and product handlers in Kiambu County, are key indicators of the training gaps in food safety in maize milling plants hence displaying a high level of significance of the socioeconomic variables as the linear predictors of HACCP towards aflatoxin contamination in the maize and the products. They require enough sensitization on the importance of food safety in protection of aflatoxin contamination

in the end products. Good Manufacturing practices and all the pre requisite programs should be well implemented and operational throughout in the milling process. Food safety knowledge dissemination from the management section should be enhanced often to improve the product handling along the whole milling chain. KAP evaluation should be used as a tool of product handling knowledge. Other aflatoxin diagnostic strategies should be necessary so as to identify available gaps. The national government is required to improve the maize millers' facilities though the ministry of agriculture and industrialization by ensuring that they have all requirements of safe maize flour milling from aflatoxin invasion the same time capacitated to fulfill all conditions of food safety as dictated in ISO 22000. Kiambu County is just one location in the whole country. Similar study needs to be conducted to the other 46 counties in the country. KEBS, as a standard body and the Food and Drug Act (FDA) are required to strictly take the initiative of installation of relevant knowledge, positive attitude and the enhancement of practices of aflatoxin reduction to maize millers.

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Conflicts of interest

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