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Sources of Aflatoxin Exposure in Kisumu County, Kenya

MI Obade[1*], P Andang'o[2], C Obonyo[3] and F Lusweti[4]
*[*1]County Government of Kisumu, Department of Health, P. O Box 721-40100, Kisumu, Kenya*
[2]Maseno University, School of Public Health and Community Development, Department of Nutrition and Health, P.O. Box 333, Maseno- Kenya
[3]Kenya Medical Research Institute (KEMRI), Centre for Global Health Research, Kisumu. P.O Box 1578, Kisumu, Kenya
[4]Kenya Agricultural and Livestock Research Institute (KALRO), Kenya

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ABSTRACT
Aflatoxins are naturally occurring group of carcinogenic toxins produced by Aspergillus flavus and Aspergillus parasiticus. The toxins affect both developing and developed worlds and are of public health importance because of their effects on human health and food safety. Reports indicate that 40% of diets in both rural and urban communities in Kenya are likely to be contaminated by the aflatoxins. Cases of aflatoxin poisoning resulting from consumption of contaminated maize have been reported yearly in Eastern Kenya,with several outbreaks of aflatoxicosis, the worst having occurred in 2004. However, data on aflatoxin levels in foods in other parts of the country is scanty. The main objective of this study was established aflatoxin levels in selected market foods in Kisumu County, Kenya. The specific objectives were: to determine the proportion of foods contaminated with aflatoxin; to determine aflatoxin levels by market place. In a cross sectional survey, 297 solid food samples selected by a combination of cluster and systematic sampling; and 80 milk samples selected from market outlets using the European Model were analyzed for aflatoxin contamination in June-August, 2013. Aflatoxin levels were analyzed using Enzyme Linked Immunosorbent Assay (ELISA) in parts per billion (ppb). Aflatoxin B_1 and M_1 levels in market foods ranged between 0 ppb to 34.5 ppb and 0.012 ppb to 0.127 ppb respectively. Sorghum had the highest aflatoxin median levels (median=14.2; IQR= (8.5-19). These results underpin the need to initiate strategies geared towards reducing aflatoxin levels in staple foods consumed in Kisumu County.

Key words: Aflatoxin, Sampling, ELISA, Parts per billion, Exposure

INTRODUCTION

Aflatoxins are food contaminants that cause liver and others cancers in human (International Agency for Research on Cancer)[IARC] [1], as well as growth faltering in young children [2]. The toxins are of public health importance because of their effects on human health and food safety [3]. Aflatoxins are produced by fungal action during food production, harvest, storage and processing and affect a large proportion of world's staple foods especially maize and groundnuts [4]. Contamination of food supplies by aflatoxin is of particular concern in rural communities of developing countries [5], where high levels have been found in staple foods, causing concerns about the quality of the food and the health implications to the consumers.

It is indicated that about 25% of the world's food could be contaminated with aflatoxins [6] and about 4.5 billion people globally exposed to aflatoxins through contaminated food[3], giving rise to concerns that aflatoxin contamination could impair food security and pose a great health risk to consumers, especially in developing countries. Although Many of the dietary staples in developing countries could be contaminated with aflatoxin, highest levels have been reported in maize and groundnuts [7]. Aflatoxin levels in most staple foods in Kisumu County have not been established.

Reports indicate that about 1.8 million Kenyans are chronically exposed to large amounts of aflatoxins [8]. Studies carried out in Kenya also reveal that more than 40% of diets in both rural and urban communities are likely to be contaminated by the aflatoxins [9]. This suggests that a big proportion of the Kenyan population risk exposure to aflatoxin and the associated health risk.

Corresponding Author: MI Obade, County Government of Kisumu, Department of Health, P. O Box 721-40100, Kisumu, Kenya.

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Cases of aflatoxin contamination in foods and aflatoxicosis have been reported yearly in Eastern Region of Kenya the worst having occurred in 2004 where 317 cases and 125 deaths were reported [10]. However, high levels of aflatoxin have been reported in maize in Nyanza compared to Eastern Region, which has been assumed to have the highest levels of aflatoxin contamination in food [11], causing concern that other parts of the country could be affected, other than Eastern Region.

Most households in Kisumu obtain their food products from own farms and from the markets [12]. It is documented that any effort to combat exposure to aflatoxin must consider the potential role of the market system in sustaining exposure [13]. Most staple foods in Kenya are marketed through informal marketing systems where products are seldom tested for aflatoxin contamination. The major food markets in Kisumu County include; Kibuye whole sale market, Kibuye open air market, Oile market, Mamboleo market, Ahero market, Kiboswa market, Holo market (Personal communication with Kisumu East District Crops Officer, 2014). Investment in drying, and storage facilities is crucial for prevention of aflatoxin contamination in market food [3]. Most of the markets in Kisumu do not have appropriate drying and storage facilities, potentially exposing the food products to extreme weather conditions and aflatoxin contamination. Some of the foods consumed in Kisumu County come from other counties and could be potential source of aflatoxin exposure (**Table 1**).

Table 1. Other Sources of Food Consumed in Kisumu County

Food Item	Source of food
Dagaa	Homa Bay, Migori, Siaya, Bondo
Rice	Busia, Tanzania, Ahero, Dominion farms
Groundnuts	Uganda, Busia, Homa Bay, Kisumu East
Cassava	Busia, Tanzania, Kisumu East, Siaya
Maize	Rift Valley, Busia, Molo, Migori
Sorghum	Busia, Uyoma, Migori, Siaya
Processed milk	Super markets
Raw milk	Nandi, Kericho, Bomet

Source: Department of Agriculture [12]

Maize, sorghum, groundnuts, cassava and rice constitute the major staple diet consumed in Kisumu County [12], and are likely to be contaminated with aflatoxins. However, emphasis in most researches on aflatoxin contamination levels in Kenya have been conducted in Eastern Region and mainly focused on maize. Given that other foods could also be at risk of aflatoxin contamination and exposure even to low levels of the toxins may have long term effect on health, studies aimed at determining aflatoxin levels in staple foods that constitute the diet of Kisumu County,and other parts of the Kenya, ought to be encouraged.

Consumption of contaminated animal feeds and improved pastures such napier grass, fodder shrubs and legumes, by animals may expose consumers to the toxin through contaminated animal products [14]. It is reported that most animal feed manufacturers rarely test imported raw animal feed materials for aflatoxins and the Kenya Bureau of Standards does not remit results of aflatoxin in feeds regularly [15]. A study carried out in Kenya to highlight existing danger of mycotoxin contamination of dairy feeds, found that aflatoxin B_1 was one of the most widely occurring and dangerous of all mycotoxins found in animal feeds [14]. A similar study by Kangethe and Langa [15], further established that 72% of the milk from dairy farmers, 84% from large and medium scale farmers, and 99% of the pasteurized marketed milk were positive for aflatoxin M_1, and 20%, 35% and 31% of positive milk from dairy farmers, medium and large scale farmers, and market outlets respectively, exceeded the WHO/FAO levels of 0.05μ g/Kg-1. The aforementioned findings confirm the presence of aflatoxin in animal based food and aflatoxin contamination through animal feed which may find its way into the human food chain, potentially endangering the health of consumers; and therefore the need to determine the aflatoxin in such foods.

A report from the then Ministry of Fisheries Development [16] revealed that Nyanza produced 90% of the total fish in the Country with *Rastrienobola argentea* (*dagaa*) contributing 47% of the fish produced in Nyanza. D*agaa* is one of the cheap sources of protein that is consumed by many Kenyans as well as a major ingredient in animal feeds [17]. In 2010, 70,000 tons of *dagaa* was produced, 70% of which went to feed industry and 30% for human consumption (MoFD, 2012). Any contamination that finds its way into feeds ends up in human consumption through the food chain. Nile perch and *dagaa* together constitute over 90% of fish of Lake Victoria [17]. In a recent study carried out in Winam Gulf of Kenya to establish determinants of carcinogenic polyclic aromatic hydrocarbons, aflatoxins and nitrosamines in processed fish, aflatoxins mean concentration of 0.33–1.58 ppb were found in sun dried *dagaa* and daily intake of aflatoxins through consumption of *dagaa* was estimated at 0.0079 ug/kg during rainy season [18].

Milk consumption in Kenya was projected at 4.1 billion litres in 2014, the highest in Sub-Sahara Africa [19]. The annual per capita consumption at household level in the rural areas was 45 litres for milk producing households and 19 litres for milk purchasing households and 145 litres for urban areas. Per capita consumption in Central and Rift Valley Regions was 144 litres to 152 litres and 38 litres to 54 litres in other Regions [20]. This translates to daily milk consumption of 0.128 litres (128 mls) in other Regions. Per capita milk consumption in Kisumu County was estimated at 31.2 litres which translates to 0.09 litres (90 mls per day) [20].

MATERIALS AND METHODS

This study was conducted in Kisumu East and Nyando Sub-Counties, Kisumu County, Kenya. Kisumu County has seven Sub-Counties (Kisumu East, Kisumu West, Kisumu Central, Kisumu North, Nyando, Muhoroni and Nyakach), with an area of 2,085.9 km^2 and a population of 968,909(Kenya National Bureau of Statistics) [21].

A cross sectional design was used to establish aflatoxin levels was used to determine the aflatoxin levels in selected market foods in Kisumu County. The cross sectional market study was conducted in Kisumu East and Nyando Sub-Counties, Kisumu County, Kenya. Based on data on food production and requirement in Kisumu County from the Department of Agriculture Annual Report 2015, and informal interviews with nutritionists, consumers and Department of Agriculture staff, common staple foods (maize, sorghum, millet, cassava, rice, *dagaa* and milk) were collected from five major markets (Kibuye wholesale market, Kibuye open market, Oile Market, Mamboleo market and Ahero market) and analyzed to determine the actual aflatoxin levels.

The study population composed of 213 bags (90kg) of dry foods (*dagaa* 63 bags, rice 34 bags, groundnuts 23 bags, cassava 41 bags, maize 46 bags, sorghum 31 bags) from 5 markets (Kibuye wholesale market, Kibuye open market, Oile Market, Mamboleo market, and Ahero market) from Kisumu East and Nyando Sub-Counties, and raw milk samples from 3 milk bazaars (Ahero, Mamboleo and Guba markets) and processed milk from 3 supermarkets in Kisumu County. The total population of milk samples in the supermarkets was unknown.

The sample size for the number of food samples to be collected from each market was calculated based on formula by Israel [22]:
$N/(1+N(e)^2)$; .where N is the population size of total available bags of each food in the market at the time of survey and e is the margin of error set at 5% (0.05) at 95% Confidence level.

Only one sample of 500g was required per bag [23], hence the total number of bags was equal to the total number of the different samples. The total population of milk samples in the supermarkets was unknown. Two hundred and nineteen dried food samples (500g each) and 80 milk samples (50 samples of processed and 30 samples of raw milk) were collected as shown in **Tables 2.**

Table 2. Sample Size Distribution for Market Food Samples

FOOD SAMPLE	Population N	Minimum sample $N/(1+N(e^2))$	Final Sampled (Table 8 below)
Dagaa	63	54	60
Rice	34	31	31
Groundnuts	23	22	22
Cassava	41	37	37
Maize	46	41	41
Sorghum	31	28	28
Raw milk	30	30	30
Processed milk	50	50	50
TOTAL	238	213	299

Of the dry foods, *dagaa* had the highest numbers of bags (63) in the market followed by maize (46) and cassava (41), while groundnuts had the lowest number of bags (23) in the market.
Six markets were purposively selected for inclusion in the survey. Based on their geographic locations, these markets served the largest population in their respective Sub-Counties. They were likely to have enough vendors with a variety of food products of interest to the study including; maize, sorghum, cassava, rice, *dagaa* (*Rastrienobola argentea*) and milk. The markets selected were: Kibuye wholesale market, Kibuye open market, Oile Market, Mamboleo market, Guba and Ahero market. Foods that formed a big proportion of the staple food in Kisumu County, according to Ministry of Agriculture 2012 Annual report [24], were chosen for inclusion in the study. The vendors were chosen if they had foods of interest to the study and gave an informal consent to have their foods sampled.

Sampling of dry foods was done using a combination of cluster and systematic sampling. A sample of five hundred grams of available maize, sorghum, polished rice, cassava, groundnuts and *dagaa,* was collected from each bag from the vendors [25]. The European model, which recommends that a 500g sample composed of five 100 g portions of milk is taken from a batch, be used for the minimum sample size and sample selection method was applied [26].

Two hundred and nineteen dried food samples (Maize, sorghum, cassava, rice, groundnuts and *dagaa*) were scooped from selling bags at different points of the bags to ensure uniformity, using respective vendor tools such as tins, and double packaged in brown paper envelopes to avoid cross contamination and moisture penetration [23]. The packages were properly labeled, coded and the sources properly recorded and were transported to Kenya Agricuture and Livestock Research Organization (KALRO) Kitale for aflatoxin analysis. Processed cow's milk samples were collected from three major supermarkets in Kisumu City and raw cow's milk samples from 3 market milk bazaars at Guba, Mamboleoand Ahero markets. Five 500 mls portions of milk were taken from each batch of milk [26] and put in 100 ml plastic bottles. A total of 80 milk samples were collected as follows: 50 processed milk samples from the 5 most common milk brands (coded for purposes of confidentiality) from three major supermarkets in Kisumu City; and 30 raw milk samples were collected from Ahero, Mamboleo and Guba market milk bazaars. The milk samples were immediately frozen and stored at -20^oC before being transferred to KALRO Kitale for analysis. Aflatoxin M_1 content was reported in parts per billion (ppb).

Aflatoxin B_1 levels in maize, sorghum, millet, cassava, rice, and*dagaa*were determined by Enzyme Linked Immunosorbent Assay [ELISA] [27]. Aflatoxin M_1 levels in milk samples were analyzed using Helica Aflatoxin M_1 Assay (Aflatoxin M_1 ELISA), with high affinity for aflatoxin M_1 [27].

Data was entered in excel (version2010), cleaned and exported to Statistical Package for Social Sciences (SPSS) software (IBM SPPS Statistics®) version 20,where variables for analysis were generated.

Prevalence of aflatoxin contamination levels in selected staple foods was determined by frequency of detectable AFB_I in food samples and expressed as proportions. Levels of aflatoxin in market food were expressed as median and IQR.

The research proposal was approved by the School of Graduate Studies, Maseno University approval process. Permission to conduct study was sought from the Maseno University School of Graduate Studies.

RESULTS

Aflatoxin in solid food and milk samples was assessed to determine contamination levels and identify samples with levels above the regulatory limits that could be potential sources of aflatoxin contamination in Kisumu Country. The KEBS limits of 10ppb apply for solid foods [28] and the Codex Alimentarius limits of 0.05 ppb apply for milk samples [29].

Aflatoxin levels ranged from 0 ppb to 35.4 ppb aflatoxin B_1 in solid food samples and 0.00 ppb to 0. 13 ppb aflatoxin M_1 in milk samples. Of the solid food samples (n = 219) analyzed, 80.8% were contaminated with aflatoxin with 12.8% above the regulatory limit of 10ppb. All (100%) of the maize, groundnuts and sorghum samples were contaminated with aflatoxin. None of the cassava and *dagaa* samples had aflatoxin levels above the regulatory limit. Maize had the samples with the highest aflatoxin levels of 35.4 ppb, but they were isolated cases hence outliers. Of the dry foods, sorghum had the highest proportion of samples (71.4%) with aflatoxin contamination levels above the regulatory limit of > 10 ppb, with a median (IQR) contamination level at 14.2 (8.5, 19); while cassava had the lowest median (IQR) aflatoxin contamination levels at 0.5 (0.5, 0.5). All the processed milk (n = 50) and raw (n = 30) milk samples were contaminated with aflatoxin. Of the total processed milk samples (n=50)**,** 38% were contaminated with aflatoxin levels above regulatory limit of 0.05 ppb, while raw milk did not have any samples above the regulatory limit for milk.

Table 3. Proportion of Food Samples Contaminated with Aflatoxin

Food Item	**n**	**Contaminated n (%)**	**Above Aflatoxin regulatory Limit n (%)**	**Aflatoxin Levels**	
				Median (IQR)***	**ppb (Min, Max)**
Dagaa	60	32 (53)	**0 (0)**	0.6 (0, 2.08)	(0.00, 2.76)
Rice	31	21(67)	1 (3)	0.5 (0, 1.2)	(0.00, 11.70)
Groundnuts	22	22 (100)	2 (9)	1.5 (0.5, 2.0)	(1.00, 27.60)
Cassava	37	33(89)	**0 (0)**	0.5 (0.5, 0.5)	(0.00, 3.50)
Maize	41	41(100)	5 (12.2)	0.5 (0.5, 1.0)	(0.50, 35.40)
Sorghum	28	28(100)	**20 (71.4)**	14.2 (8.5, 19)	(1.00, 24.50)
Total (AFB_1)	**219**	**177 (80.8)**	**28 (12.8)**	**0.70 (0.05, 2.08)**	**(0.00, 35.40)**
Processed milk	50	50 (100)	19 (38)	0.04 (0.03, 0.07)	(0.010, 0.13)
Raw milk	30	30 (100)	**0 (0)**	0.008 (0.005, 0.01)	(0.002, 0.012)
Total milk (AFM_1)	**80**	**80 (100)**	**19 (23.8)**	**0.03 (0.01, 0.50)**	**(0.0002, 0.13)**

*** Descriptive statistics were used to generate proportions, medians and interquartile ranges.

All *dagaa*, cassava and raw milk samples had aflatoxin levels below 10 ppb; with some of the samples having no detectable aflatoxin. Some maize samples had high aflatoxin levels, but all of these were outliers. When the median contamination levels were calculated, only sorghum had median aflatoxin levels above the regulatory limit of 10 ppb (**Table 3).**

Aflatoxin was assessed by market to determine potential source markets of aflatoxin contaminated foods in Kisumu County. **Figure 1** shows the overall median and IQR aflatoxin levels in total food samples for each market.

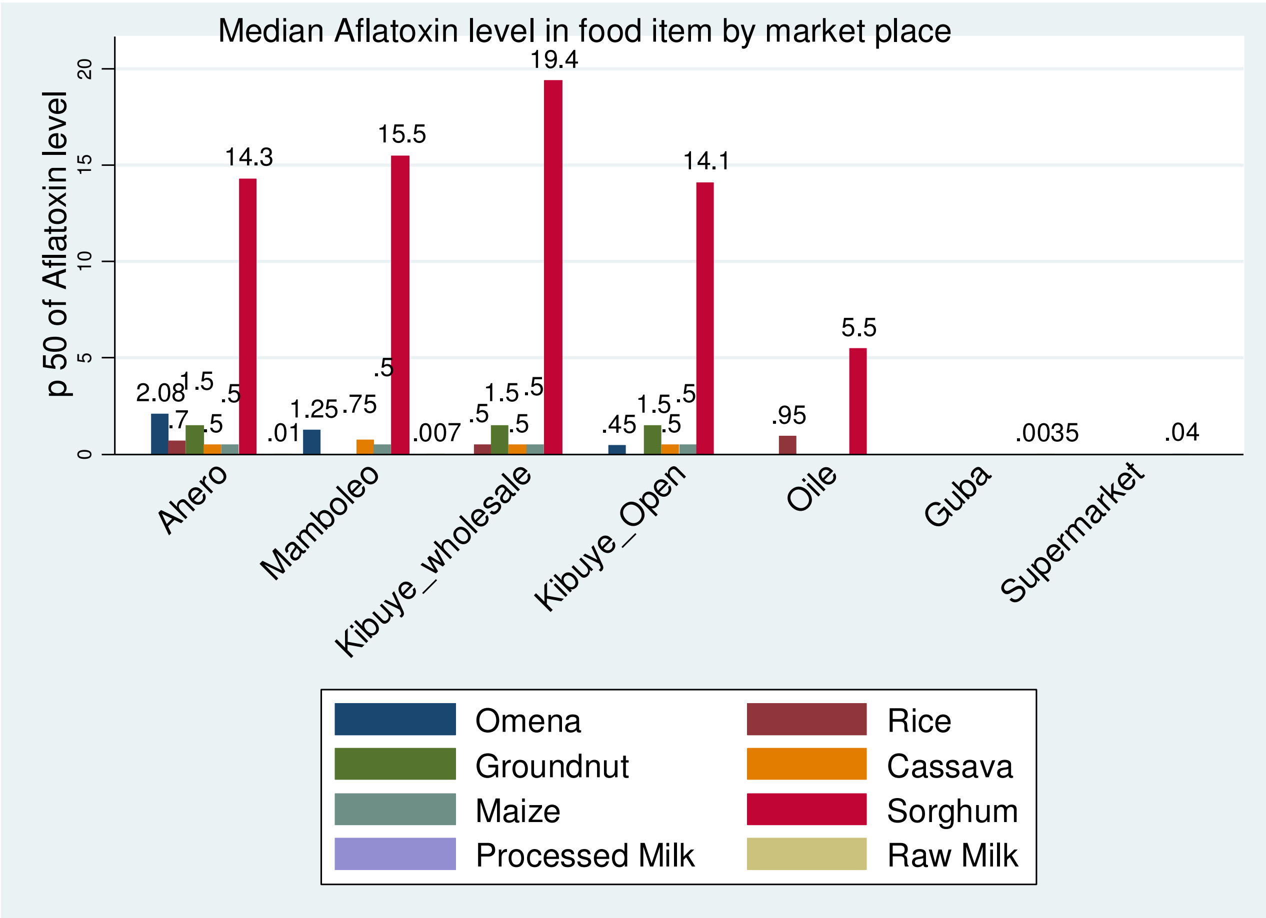

Figure 1. Distribution of aflatoxin in food item by market place

Sorghum had the highest median aflatoxin levels and the levels were highest for sorghum from Kibuye Wholesale Market compared the other markets.

Table 4. Aflatoxin Levels (Ppb) by Market Place

Market	Number of samples analyzed	Median (IQR)***
Ahero**	64	0.7 (0.5, 2.08)
Mamboleo	42	0.5 (0.01, 1.8)
Kibuye Wholesale	36	0.5 (0.5, 1.75)
Kibuye Open Air market	65	0.5 (0.5, 7.3)
Oile Market	19	0 (0, 0.7)
Guba*	10	0.004 (0.002, 0.006)
Supermarkets*	51	0.04 (0.03, 0.07)
*** Only milk samples.**		

** Dry foods and milk samples.

*** Descriptive statistics were used to generate medians and interquartile ranges.

Results in **Table 4** indicate aflatoxin levels in foods by market place. Food samples from Kibuye open air and Ahero markets had the highest overall aflatoxin median (IQR) levels, 0.5 (0.5, 7.3) and 0.7 (0.5, 2.08) respectively, compared to 0 (0, 0.7), 0.5 (0.01, 1.8) and 0.5 (0.5, 1.75) for former Oile, Mamboleo and Kibuye wholesale markets respectively.

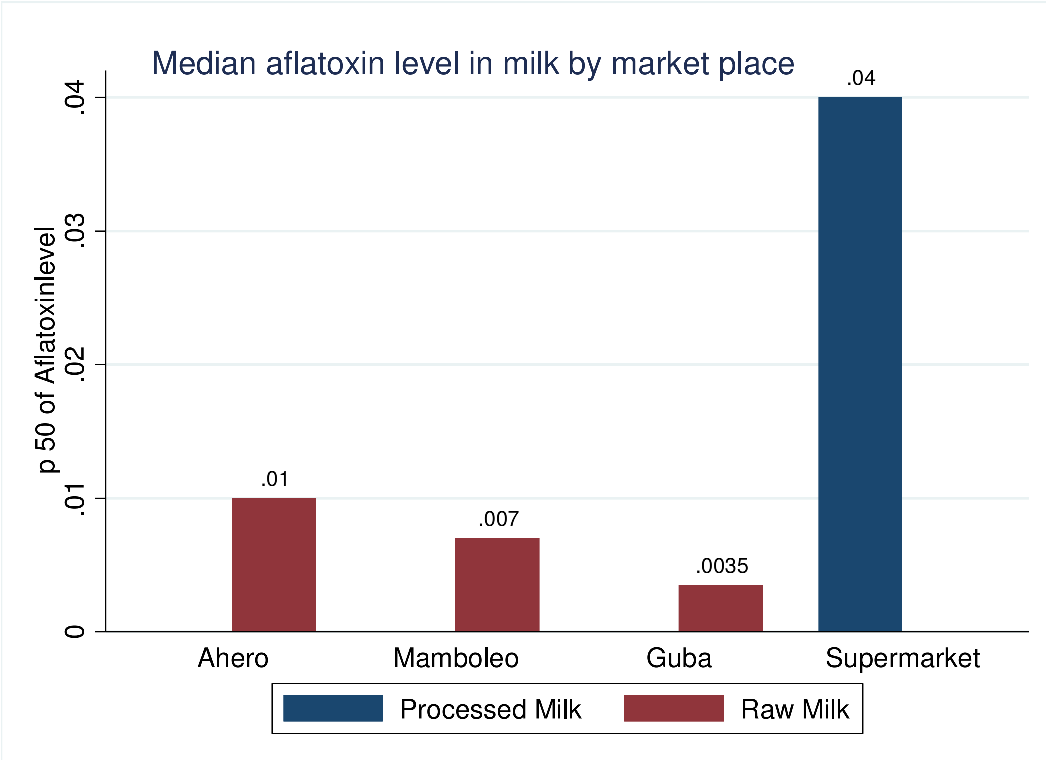

Figure 2. Median aflatoxin levels in milk by market.

Processed milk had the highest median aflatoxin M_1 level (0.04 ppb) compared to the other markets. Raw milk from Ahero market had highest median M_1 aflatoxin level (0.1 ppb) Guba market had the lowest median M1 aflatoxin level (0.035).

DISCUSSION

In this study, selected market foods were analyzed to identify foods which could be potential sources of aflatoxin exposure in Kisumu County. All the samples of maize, sorghum, groundnuts and milk were contaminated with varying levels of aflatoxin, indicating that they are all sources of dietary aflatoxin exposure. All the foods except *dagaa*, cassava and raw milk had samples with aflatoxin levels above the regulatory limits; therefore they are sources of high aflatoxin exposure as defined in this study. Sorghum had the highest number of samples contaminated with aflatoxin and also the highest median aflatoxin levels reflecting the most consistent contamination of all the foods. Although maize had the samples with highest aflatoxin contamination levels, they were isolated samples. This study established that although sorghum, maize, groundnuts and rice are sources of aflatoxin contamination at levels above the Kenya regulatory limit, such contamination occurs in less than 50% of total samples and only translates to consistent contamination in sorghum. These results are of concern for several reasons:

First, the foods analyzed form a major component of staple foods produced and consumed in Kisumu County [24]. Whereas previous studies on aflatoxin contamination internationally have focused on maize and groundnuts [3], little attention is given to other foods which could be potential sources of aflatoxin contamination. Results from our study show that rice, *dagaa,* sorghum and processed milk may also expose individuals to aflatoxins above regulatory limits and hence may pose a health risk to consumers in Kisumu County. This is especially so if individuals purchase even isolated samples with high contamination levels, given that aflatoxin persists in the system for a considerable period of time. In a simulation study from the data in this study, it was indicated that if the food items assessed were used as complimentary foods for infants, assuming consumption of cereal and tubers and milk, infants could have aflatoxin intakes as high as 110 ng (0.110µg)/kg body weight per day [30] and pregnant women

150 µg/ kg body weight per day [31]. These figures are higher than the findings from a study carried out in The Gambia, West Africa, where residents of Keneba, West Kiang, were found to be exposed to aflatoxin originating from several foods with an intake ranging from 0 to 29 µg/day [30].

Secondly, the findings of this study reveal that about 90% of the foods were contaminated with aflatoxin compared to the reported 25% of the world food contamination[6]. However, unlike the FAO's 25% that takes into consideration aflatoxin contamination of all foods consumed, this study only focused on selected samples comprising of the commonly consumed foods in Kisumu County, therefore bias cannot be ruled out in the high percentage. Nonetheless, these foods form a big proportion of the foods consumed in Kisumu County and their flours are commonly used in complimentary foods by most households in the County [24], hence the results of this study may be a good reflection of average consumption of aflatoxin. Data from weighed food records from one day dietary intakes by 20 participants showed that 19 consumed at least one meal of ugali, 9 at least one meal of porridge, 10 consumed at least one meal of rice, 20 at least one meal of tea with milk, and 9 at least one meal of omena in one day. These data showed that cereals, milk, as well as omena were commonly consumed in Kisumu County and could be possible sources of aflatoxin exposure.

Third, although maize and groundnuts have been considered the major sources of aflatoxin and the results of this study showed that sorghum may also require equal attention given its production and wide consumption in the region [12]. In this study, the proportion of sorghum samples with detectable aflatoxin levels was higher than that of maize and groundnuts, indicating more widespread contamination in sorghum than in other foods. This suggests that sorghum could be an emerging possible source of high levels of aflatoxin compared to maize. Therefore, although the findings of this study are based on cross-sectional data, only reflecting contamination at one time point, the findings of this and the other studies, in combination, point to a need to confirm whether or not this contamination persists over time. Furthermore, from the food frequency and 24-hour dietary recall surveys, sorghum was used in preparation of *ugali* (cooked paste made from flour and water) and porridge consumed by both adults and young children.

Fourth, sorghum, rice and cassava are among the major food crops being promoted as food security crops by the National and County Governments under the Traditional High Value Crops and Rice Promotion Programmes [12]. This has resulted in increased production and by extension, consumption of these foods. At the levels detected through the analysis, sorghum and rice could be among major contributors to aflatoxin exposure in Kisumu County, other than groundnuts and maize. Cassava and *dagaa* (*Rastrineobola argentea*) had the lowest aflatoxin levels among dried foods.

The levels of aflatoxin in *dagaa* reported in this study were similar to those reported in samples of *dagaa* in Winam Gulf of Kenya Kisumu [18]. Given that Nile Perch and*dagaa* together constitute over 90% of fish of Lake Victoria and that 70% of *dagaa* from Nyanza region is used as animal feed [16] and 30% as human food, there is need to ensure that fish intake does not expose consumers to aflatoxins. Further, given that the detection limit for both aflatoxin B_1 and aflatoxin M_1 was < 1 ppb, even samples with non-detectable levels could still contribute to the total aflatoxin exposure in Kisumu County.

Processed milk, but not raw milk, had samples with contamination levels above the Codex Alimentarius regulatory limits. These findings concur with results from the study carried out Kenya which established that 72% of the milk from dairy farmers, compared with 99% of the pasteurized marketed milk was positive for aflatoxin M_1, and 20%, and 31% of positive milk from dairy farmers, and market outlets respectively, exceeded the WHO/FAO levels of 0.05µg/Kg-1. High levels of aflatoxin in processed milk could have resulted from aflatoxin contaminated animal feed concentrates fed to the animals [15].

Codex Alimentarius recommends a regulatory limit of 0.05µg/kg for countries with strict regulatory measures for aflatoxin $M_{1;}$ and 0.5µg/kg for other countries [29]. Currently, Kenya does not have set minimum regulatory limit for aflatoxin M_1 for milk [28], whose consumption is high among the general population, infants and young children. Given that mean aflatoxin M_1 concentrations of 0.023 µg, 0.05 µg and 0.5 µg in milk are associated with 9.4, 20 and 200 cancer cases per year per 10^6 people [29], the levels in processed milk in Kisumu County should spur some action from respective authorities. Therefore, based on the levels of aflatoxin established in processed milk, there is need to institute quality control measures to ensure continued safety of milk consumers; and given that milk forms a big proportion of the first food an infant is given before introduction of other foods.

In considering food contamination by source, food samples from Ahero and Kibuye open air markets had the highest median aflatoxin levels, while food samples from Oile market had the lowest aflatoxin levels. Ahero area is characterized by frequent flooding during the rainy seasons and prolonged drought during the dry periods [32], conditions which favor growth of moulds. Kibuye Open Air Market did not have properly constructed shelters for dry foods; the foods were therefore exposed to extreme weather conditions making them vulnerable to aflatoxin contamination and proliferation of aflatoxins. Oile Market, on the contrary, had temporary structures which provided some form of protection against harsh weather conditions; which could explain the low levels of aflatoxin in foods from that market.

Kisumu County is not food secure and some of the foods consumed in the County are sourced from outside the County based on the figures on food production and requirements [12] (**Table 2.**). Some of the sources of the food consumed are as indicated: *Dagaa* (Homa Bay, Migori, Siaya and Bondo); Rice (Busia, Tanzania, Siaya); Groundnuts (Uganda, Busia, Homa Bay); Maize (Rift Valley, Busia, Molo, Migori); Sorghum (Busia, Uyoma, Migori, Siaya), Raw milk (Nandi, Kericho, Bomet) (**Table 1).** Traceability of the food sources is important if efforts to minimize aflatoxin levels in the foods in Kisumu County are to succeed.

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