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Research Article

Assessment the Level of Awareness of Aflatoxin Contaminations in Maize-Based Meals Among Boarding School Personnel

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Abstract

Tanzania is a tropical country that lies few degrees south of the equator The coast area includes regions such as Dar es Salaam and Coastal region which are hot and humid with cooling breezes of the Indian Ocean. Awareness of society is a crucial aspect of ensuring the safety and quality of food. One of the risk factors in food safety is the presence of aflatoxin in various foods such as cereals, and groundnuts. The aim of this study was to assess the levels of awareness of aflatoxin B1 contamination in maize and maize flour used for meals in boarding secondary schools. A total of 90 respondents from 30 schools from 7 districts of the two regions were interviewed. Semi-structured questionnaires were used to collect information and the survey showed that 74.4% of the respondents were aware of aflatoxin contamination. 85.6% of respondents know that aflatoxin is found in food and only 14.4% were not aware. 74.4% were capable of selecting the correct list of food that can be contaminated with aflatoxin while 11.1% selected the wrong list. 14.4% of the respondents were unable to select the list of foods that can be contaminated with aflatoxin. These results indicate that most of them are aware of the issue of aflatoxin contamination in maize and its products which is good for reducing aflatoxin contamination in food products and its effect. An effective and broad awareness program for the society including boarding school personnel and students on good management of food for prevention of aflatoxins contamination and its health effects is necessary, as maize and its products are the most consumed grain in the study area.

Keywords

Awareness of Society, Aflatoxin, Boarding Secondary Schools

1. Introduction

Mycotoxins are small molecular weight compounds produced by some filamentous fungi or molds [11]. When the right temperature and humidity are present, mycotoxins can develop on a variety of foods and feeds, posing a serious risk to health of humans and animals [10]. There are more than 400 known types of mycotoxins, but aflatoxins especially aflatoxin B1 (AFB1) remain the most toxic. Hence, classified by the International Agency for Research on Cancer as a category 1 carcinogen. Most of them are produced by *Aspergillus* section Flavi group – *Aspergillus flavus*, *Aspergillus nomius*, and *Aspergillus parasiticus*. These aflatoxigenic correct spelling species have been

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recovered globally from a wide range of foods including maize, wheat, oil seeds, peanuts, and other nuts [13]. Maize is an important staple food crop grown in all regions of Tanzania and is also used as a source of income to reduce poverty and ensure food security in various regions [36]. The crop is susceptible to fungal contamination both in the field and during storage [38]. Contamination during storage can occur when the combination of factors such as moisture and relative humidity, oxygen availability, and damaged or broken grain kernels occurs [27]. The contamination of maize by aflatoxins makes it undesirable for consumer health [38]. Consumption of foods containing high levels of aflatoxins has been associated with deleterious effects on human and animal health. Negative effects of the toxins on human and animal health include; liver and kidney infections, immunosuppression, mutagenesis, teratogenesis, and carcinogenesis [38]. Chronic exposure to high levels of aflatoxin can cause various clinical problems such as bile duct proliferation (BDP), edema, anorexia, hepatitis, kidney malfunctioning, acute jaundice, and fatigue, all of which may subsequently result into death [12]. Contamination is often unavoidable in many African countries as they do not test crops for aflatoxins, a low level of awareness and knowledge of aflatoxins which results in the consumption of contaminated foods [17]. Post-harvest loss refers to the decline in the quantity and quality of maize. Aflatoxin-producing molds grow exponentially in conventional multi-month storage as a result of a combination of heat and high humidity [39]. It occurs when aflatoxin-producing mold infests maize grains and causes spoilage. The contaminated grains become moldy and unhealthy for consumers [4]. Aflatoxin contamination in maize is positively influenced by a number of practices including improper drying, farmers' production methods, storing the crop with other aflatoxin-contaminated grains, pre- and post-mature harvesting, and poorly constructed storage structures [25]. Also, environmental conditions such as high temperatures and relative humidity encourage fungal infection and the development of aflatoxin contamination in crops [12]. Moreover, insufficient understanding and awareness of the toxins among farmers, merchants, and consumers is the reason for high levels of aflatoxin contamination in stored maize [24]. Despite the efforts made by the Tanzanian government to fight this problem, the nation still faces the challenges of post-harvest losses of maize during the storage period. The objective of this study is to assess the level of awareness of aflatoxin contaminations in maize-based meals among boarding school personnel. Information obtained from the study can be useful in gathering critical information for developing methods for raising the level of awareness, knowledge, perception, and attitude among them on aflatoxin contamination in school meals.

2. Material and Method

2.1. Study Area

The study was conducted in Dar es Salaam and the Coastal region. Dar es Salaam is the largest city in Tanzania. It is located on the Indian ocean coast. Geographically, Dar es Salaam is located 6.7924 ℃South and 39.208 ℃East. It has an estimated population of 5,383,728 (Census 2022). In Dar es Salaam boarding schools from three districts (Kinondoni, Kigamboni, and Ubungo) were surveyed. The Coastal region is located northeast and southeast of the Indian Ocean. Its capital is the town of Kibaha. The Region borders, Tanga region to the north, the Morogoro region to the west, the Lindi region to the south, and the Dar es Salaam region to the east. According to the 2022 national census, the region had a population of 2,024,947 (Census 2022). In the coastal region boarding schools were surveyed in four districts (Kibaha town, Kibaha rural, Mkuranga, and Bagamoyo).

2.2. Study Design

A cross-sectional design using a semi-structured questionnaire was adopted for data collection on aflatoxin awareness among boarding school personnel to obtain relevant information regarding their knowledge and awareness of aflatoxin contamination in maize flour. The briefing was done so that prospective respondents were motivated to participate in the interview. Demographic information was among the collected information and a questionnaire aimed at understanding the knowledge of aflatoxin of the respondents. The questionnaires were first prepared in English and then translated to Swahili so that it would be easier for the respondent to understand and give appropriate answers based on their understanding or awareness. It was then pretested, to check for its suitability.

2.3. Sample Size Determination

Seven districts were randomly selected from two regions (Dar es Salaam and Coast region) based on the criteria of having large number of boarding secondary schools. The sample size was estimated using the Kothari equation (Kothari and Garg, 2014):

$$n = \frac{z^2 p(1-p)}{e^2} \quad (1)$$

where, n= sample size, Z= standard variate at a given confidence level, for this study a 95% confidence level = 1.96 and e = acceptable error (the precision/ estimation error) set at 8% (0.08) for this study.

$$\mathrm{n} = \frac{(1.96)^2(0.05)(1-0.05)}{(0.08)^2} \approx 30 \quad (2)$$

A semi-structured questionnaire was used to collect information on aflatoxin awareness in thirty schools and three participants from each school (the head teacher, storekeeper/meal teacher, and kitchen personnel) were interviewed.

2.4. Data Analysis

Statistical Package for Social Sciences (SPSS) 27 software was used to enter data on boarding secondary school personnel awareness and knowledge of aflatoxin contamination in maize flour. Descriptive analysis was carried out to obtain descriptive results, that is, the frequency and percent distribution of the assessed variables from the data set. A value less than 5% was considered significant throughout the conducted analyses.

3. Results and Discussion

3.1. Socio-Demographic Characteristics of the Respondents

Levels of awareness of aflatoxin contamination and other fungal toxins vary with various socioeconomic characteristics such as age, gender, and education levels. The result of demographic characteristics shows that (68.9%) of the participants were male and (31.1%) were female. A similar result was reported in Uganda where a small number of females participated in school leadership as school head teachers, school meal teachers, and school chiefs [22]. Likewise, the study conducted in Kenya, found more females to be informed of the danger caused by fungal toxins and cautious of moldy than males despite their low participation [37]. Furthermore, age group is an important factor in social analysis since different age groups perform a variety of activities as described by [21]. This study found the highest proportion (76.7%) of respondents ranged between the ages 31 to 50 and the lowest (10%) was above the age of 50. The first group (aged 31 to 50) had a higher awareness of aflatoxin issues than the other group and this was proven by the study done by who observed that the aged group was more aware of aflatoxin contamination [22]. However, the results of this study are conversely against the study conducted in Vietnam, where young people aged (21–29) were found more informed or aware about aflatoxins in crops than the older groups [22]. For education levels, the study found that the majority of respondents had university and college education i.e., 11.1% and 58.9% respectively surpass those with primary and secondary education 15.6% and 14.4% respectively by having higher awareness of the aflatoxin issue compared to other groups. People with a high education had a higher level of aflatoxin awareness compared to people with low education [9]. Another study with same finding was reported that education level has a positive effect on aflatoxin awareness [34]. This difference in awareness might be due to the reason that most respondents were found to be exposed to live/social sciences-based studies, a scenario reported by [3]. Moreover, the occupation of most respondents (head teacher 33.3%, meal teacher 33.3%, and storekeeper 22.2%) have attained higher education and hence were more aware of aflatoxin contamination than surveyed school chiefs (11.1%) who have little or unaware of aflatoxin contamination in maize and maize flour.

Table 1. *Demographic characteristics of the respondents (n = 90).*

Characteristics	Frequency (Percentage)
Gender	
Female	28 (31.1)
Male	62 (68.9)
Age categories in (years)	
19 to 30	11 (12.2)
31 to 50	69 (76.7)
Above 50	10 (11.1)
Education Level	
Primary	14 (15.6)
Secondary	13 (14.4)
College	10 (11.1)
University	53 (58.9)
Occupation	
Headteacher	30 (33.3)
Meal teacher	30 (33.3)
Chief	10 (11.1)
Storekeeper	20 (22.2)

3.2. Assessment of Respondent Awareness on Aflatoxin Contamination in Maize and MAize Flour

Almost three-quarters (74.4%) of respondents were aware of the aflatoxin contamination in maize and maize flour. This level was relatively low as compared to the 93% reported in Kenya and higher than the 20% reported in Kilosa district in Tanzania [14, 1]. Furthermore, epidemiological events that killed a number of people in Kenya due to aflatoxicosis were another reason that raised a louder alarm on aflatoxin contamination [2]. A quarter of respondents (25.6%) who had not heard about aflatoxin contamination mostly had attained a low level of education (primary and secondary education). The rest of the respondents (74.4%) obtained the information through neighbors and friends, and written resources. A study reported that 58.9% of respondents got information from friends and mass media [15, 31]. This indicates that just a few

of them got information about aflatoxins through reading, hence there is scarcity of written resources on aflatoxins and seminars from experts. In order to increase awareness among people, including boarding secondary school personnel, the government institutions responsible for ensuring the safety and quality of food should regularly (at least twice or once a year) provide seminars and training to boarding school personnel on aflatoxin contamination in food. Data indicated that (85.6%) of respondents knew that aflatoxin can be found in food and (74.4%) selected the correct list of aflatoxin-contaminated food. In addition, about (62.2%) of respondents correctly identified the color of the aflatoxin-contaminated maize, and (56.7%) selected the correct color of the contaminated maize. These results are contrary to the study conducted by [26] who reported that the majority (66.8%) of the respondents were not able to identify the presence of fungal growth on cereals crops by using the color of the grains. Safety criteria when buying food especially one that is used by a large community are very important to reduce health effects that might be caused by the consumption of unsafe food. The study found about (61.1%) of the respondents in both regions had the criteria of buying maize flour for meal preparation at school and some of the criteria that were mentioned by the respondents include checking the color of the maize kernel, and well-dried maize kernel. Also, checking the expiration date of maize flour, inspecting the maize kernel before the milling process, buying maize flour that has a TBS mark, buying maize stored for a short period of time and buying undamaged maize. The mentioned criteria are important to be considered when buying maize or maize flour to reduce the risk of contaminated maize flour used to prepare boarding school meals for students. According to the study, post-harvest mitigation strategies for minimizing aflatoxins levels in maize and maize products include de-hulling maize and avoiding damaged or broken grains/kernels [20]. Moreover, post-harvest screening to remove contaminated seeds appears to be promising methods to reduce aflatoxin contamination. Early removal of high-risk seeds such as those that are damaged, immature, or discolored, should be an effective way to prevent further contamination and increase the groundnuts/maize' value. [7]. The study found that (83.3%) of the respondent use de-hulled maize flour because it is liked/favored by students. Other given reasons include reduce pesticide residues, de-hulled flour doesn't spoil fast compared to un-dehulled maize flour and few of the respondents said that it reduces aflatoxins risks. Most of the given reasons are not useful in reducing the risk of aflatoxin contamination in food as it was observed that one of the methods of reducing or eliminating aflatoxin in maize and maize products included cleaning the cereal by sorting, washing the food before processing and de- hulling grain mechanically. Cleaning and de-hulling were also noted to be safer as these methods are unlikely to produce other toxins that would be harmful to human health [29].

Proper storage of maize and maize flour is an important in factor to reduce aflatoxin contamination in various foods. In this study, 91.1% of the respondents were aware that long storage time, untreated maize kernel, and improper drying of stored maize kernel may lead to aflatoxin contamination. Furthermore, all respondents (100%) concurred that poor storage conditions promote mold/fungal growth in the stored food. The growth of aflatoxigenic fungi is directly related to the production of aflatoxin. The primary factors influencing fungal growth in stored food products are the moisture content and temperature of the commodity [6]. Food grains are normally harvested at higher moisture content and then dried to bring down the moisture content up to a safe level before storage. Thus, delay in drying to safe moisture levels increases risks of mold growth and mycotoxin production. Post-harvest contamination can occur if crop drying is delayed. It can also occur during the storage of the crop if moisture exceeds critical values [16]. A study revealed that fungal spoilage of stored commodities and aflatoxin production highly depends on several important factors including moisture content, relative humidity in the air, and temperature of the environment [8]. Aflatoxin contamination is also promoted by stress or damage to the crop, insect activity, poor storage practices, and inadequate drying of the crop. Aflatoxin contamination is a perennial risk between 40 ℃N and 40 ℃S of the equator. This area faces high temperature and hence care should be taken during harvesting and post-harvest storage of the grain and their products in order to reduce or eliminate aflatoxin contamination. Tanzania is one of the tropical countries facing the problem of aflatoxin in cereal including maize. Maize is the major cereal consumed in Tanzania with annual per capita consumption of about 112.5 kg, and national maize consumption is estimated to be three million tons per year [33]. Most boarding secondary schools surveyed indicated that (56.7%) of students use meals that had been prepared from maize three times a day (morning taking porridge as breakfast, stiff porridge as lunch and dinner) and (41/1% of respondent indicated he use of maize meal for all seven days of a week. If the maize flour used to prepare meals for the student is contaminated with aflatoxins, there is high possibility for students to be affected by the toxin. Furthermore, the results show about 97.8% of the respondents were aware that consumption food contaminated with aflatoxin may cause health effects to humans. In addition, 86.7% of the respondents correctly identify the health effects which might be caused by consumption aflatoxin contaminated food. Many studies have reported that regular intake of aflatoxins contaminated food may cause health effects which is (acute and chronic aflatoxicosis). Exposure to high levels of aflatoxin can result in acute human aflatoxicosis leading to jaundice, oedema, GI hemorrhage, and ultimately death. There have been various reported outbreaks of human aflatoxicosis in Africa, including outbreak in the eastern and central provinces of Kenya in 2004 in which death to 120 people [30, 5]. Apart from these acute effects, aflatoxins have a wide range of negative health consequences and have been shown in many

studies to be hepatotoxic, teratogenic, mutagenic, genotoxic, and hepatocarcinogenic [32, 35].

Table 2. *Respondent's knowledge and awareness of aflatoxin contamination in maize and maize flour.*

Variable	Response	Frequency (percentage)
Awareness on aflatoxin	Yes	67 (74.4)
	No	23 (25.6)
Aflatoxin found in food	Yes	77 (85.6)
	No	13 (14.4)
List of Aflatoxin-contaminated food	Correct	67 (74.4)
	Incorrect	10 (11.1)
	None of the above	13 (14.4)
Identification of aflatox-in-contaminated maize and maize flour	Yes	56 (62.2)
	No	34 (37.8)
Colors of contaminated maize	Grey-green or yellow-green	51 (56.7)
	Black-green or red-green	6 (6.7)
	None of the above	33 (36.7)
Safety criteria used during buying maize or maize flour	Yes	55 (61.1)
	No	35 (38.9)
Safety criteria	Check the color of the maize, undamaged maize kernel, and well-dried maize kernel	14 (15.6)
	Check the expiry date of maize flour, and inspect dehulled maize before the milling process	12 (13.3)
	Pack of maize flour which has a TBS mark	15 (16.7)
	Buy maize kernel which is stored for a short time from a supply store	9 (10.0)
	Buying undammed maize kernel	9 (10.0)
	None of the above	31 (34.4)
Dehulled maize used to pre-pare the meal	Yes	75 (83.3)
	No	15 (16.7)
Reasons for dehulled maize	To reduce aflatoxin risk	4 (4.4)
	Dehulled flour liked by the student	57 (63.3)
	Dehulled maize flour does not spoil fast compared to un-dehulled maize flour	1 (1.1)
	To reduce pesticide residues	12 (13.3)
	None of the above	16 (17.8)
Poor storage conditions pro-mote mold	Yes	90 (100.0)
	No	-
Time taken to store maize and maize flour before use	Less than one month	79 (87.8)
	Three month	11 (12.2)
Consumption of contaminated food can cause health effects on human	Yes	88 (97.8)
	No	2 (2.2)

Variable	Response	Frequency (percentage)
Health effects caused by eating aflatoxin-contaminated food	Nausea, vomiting, abdominal pain, seizures acutely, and cancer	78 (86.7)
	Headache, anemia, diarrhea, and fever	10 (11.1)
	None of the above	2 (2.2)

3.3. Perception of Respondents Towards Inspect Ion by an Authority That Is Responsible for Ensuring the Safety and Quality of Food

Government institutions that are responsible for ensuring the safety and quality of food are important stakeholders in reducing or eliminating aflatoxin contamination in food including food used in boarding schools. This is because these institutions are the ones responsible for inspecting any food operating facilities in Tanzania including school kitchens and school food stores, and providing seminars and training to school personnel on the important tips for ensuring they provide students with food that is safe.

Table 3. *Shows the percentage of respondent perceptions of inspection by government authorities or institutions that are responsible for ensuring the safety and quality of food.*

Variable	Response	Frequency (percentage)
Government institution that regulates the safety and quality of food	Yes	63 (70.0)
	No	27 (30.0)
Government institutions	TBS	46 (51.1)
	TFDA	16 (17.8)
	OSHA	1 (1.10)
	None of the above	27 (30.0)
Inspected of the school kitchen and store	Yes	39 (43.3)
	No	51 (56.7)
Frequency of inspection	Once or twice a year	38 (42.2)
	Not inspected at all	48 (53.3)
	None of the above	4 (4.4)
Training on aflatoxins	Yes	3 (3.3)
	No	87 (96.7)
Government institution trained	OSHA	2 (2.2)
	District nutrition commit	1 (1.1)
	None of the above	87 (96.7)

In this study, (70%) of the respondents were aware of a government institution that regulates the safety and quality of food, and over 51.1%) correctly mentioned the institution responsible for inspection (i.e., TBS). Moreover, the study found most (56.7%) of the school kitchens and stores are not inspected, and the majority of the respondents (96.7%) did not receive any seminar/training. Regular inspections of school kitchen facilities and seminars are important to increasing awareness among school personnel regarding reducing or eliminating the consumption of aflatox-

ins-contaminated food by boarding school students. Studies reported that training, seminars, and workshops on aflatoxins increase awareness among maize traders' stakeholders [18, 19]. Similarly, a study revealed that health inspection plays an important role in protecting the public from foodborne illness outbreaks by carrying out duties such as routine inspections, food safety training programs provisions, and investigating suspected foodborne illnesses [23]. Other studies reported that stakeholder farmers' knowledge of aflatoxin in large amounts is attributed to farmer field schools and training conducted with agricultural extension officers in the study area [28].

4. Conclusions

In light of the data obtained in the seven surveyed districts (Mkuranga, Bagamoyo, Kibaha town, Kibaha rural, Kinondoni, Ubungo, and Kigamboni) in the Coast and Dar es Salaam region, it was indicated that boarding school personnel were aware of aflatoxins contamination in maize and maize flour which is vital in improving food safety in the country. However, most boarding school chiefs in the research area were observed to have low awareness level of aflatoxin contamination, which might increase the risks of students consuming aflatoxin-contaminated food because these people are the ones who deal directly with food preparation at school. Therefore, there is a need to introduce training programs to these people on issues such as how they can identify aflatoxin-contaminated maize flour, manage the safety and quality of food products in their kitchen, and other important food safety tips. Also, all government institutions responsible for controlling the safety and quality of food should play their role in this area so that the community will increase their knowledge on different aspects regarding food safety in order to reduce the health effects that can be caused by consumption of unsafe or contaminated food. The study recommends the urgent development of an effective and broad school community awareness program on aflatoxin contaminations in maize on occurrence, causes, and conditions that promote aflatoxin contamination in the stored food products including maize flour, and health effects in humans. It is important that consumers and all stakeholders along the maize value chain be educated on the potential harmful effects of AFB1 on human health.

Abbreviations

TBS: Tanzania Bureau of Standard
TFDA: Tanzania Food and Drug Authority
OSHA: Occupational Safety and Health Authority
BDP: Bile Duct Proliferation

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Conflicts of Interest

The authors declare no conflicts of interest.

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