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Mycotoxin Contamination in Cereal Grains and Associated Risk Factors: A Case Study of Iringa Municipality, Tanzania

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Abstract

Background: Mycotoxins pose significant health risks to humans and animals, including acute aflatoxicosis from high-level exposure and chronic effects like increased liver cancer risk and immune suppression due to long-term low-level exposure. These risks are exacerbated among individuals with hepatitis B virus (HBV). In children, consumption of contaminated foods can lead to stunting and impaired growth.

Methods: A cross-sectional study was conducted to investigate risk factors for mycotoxin contamination in cereals within Iringa Municipality, Tanzania. The study enrolled 296 participants across four wards—Kwakilosa, Mlandege, Kihesa, and Ruaha—selecting two streets from each ward. A minimum of 25 respondents per street were recruited using quota and convenience sampling techniques. Data collection involved administering questionnaires to assess community knowledge on mycotoxin contamination and using a checklist to evaluate storage conditions and facilities for cereals.

Results: Most respondents (36.2%) were aged between 29–39 years, while only 3.6% were above 61 years. Notably, 87.2% lacked knowledge of mycotoxin contamination in cereals, with only 12.8% demonstrating some awareness. Storage conditions were suboptimal, with 56.6% of storage rooms lacking proper ventilation, and 67.1% of cereals stored in rooms without ceilings. Additionally, 60.8% of respondents leaned cereal bags directly against walls, increasing moisture absorption and fungal growth risks. While 86.7% cleaned packaging materials before use, only 46.9% and 44.8% cleaned storage rooms and milling machines, respectively. Most participants (80.4%) used woven sacks, whereas 22.4% and 46.9% used pallets and tarpaulins, respectively.

Conclusion: A significant proportion of respondents (87.2%) lacked knowledge about mycotoxin contamination in cereals. Inadequate storage practices were prevalent, with 77.6% storing cereals on bare floors and 60.8% leaning bags directly against walls. Additionally, 67.1% of storage areas lacked ceilings, further increasing contamination risks. Improved knowledge dissemination and better storage practices are critical to mitigating mycotoxin contamination in cereals.

Keywords: Mycotoxin; Aflatoxin; Risk factors; Contamination; Cereals; Storage; Pallet

Introduction

Mycotoxins are naturally occurring toxic secondary metabolites produced primarily by filamentous fungi such as *Aspergillus flavus* and *Aspergillus*

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parasiticus. These fungi thrive under diverse atmospheric conditions and can contaminate agricultural products at various stages, including pre-harvest, post-harvest, storage, transport, and processing [1]. Among the diverse mycotoxins, aflatoxins and fumonisins are of particular public health concern due to their wide occurrence in food products and their severe chronic and acute health effects in humans [2-4].

Aflatoxins, such as aflatoxin B1 (AFB1), aflatoxin B2, aflatoxin G1, and aflatoxin G2, are highly toxic compounds. AFB1, in particular, is recognized as one of the most potent naturally occurring carcinogens [5]. Chronic exposure to low levels of aflatoxins has been associated with an increased risk of liver cancer, especially in individuals co-infected with hepatitis B virus (HBV). Additionally, acute aflatoxicosis outbreaks have led to significant morbidity and mortality. For instance, a 2004 outbreak in Kenya resulted in 317 cases of acute hepatitis and 125 deaths [7] Similar incidents have been reported in Tanzania, where aflatoxin contamination of maize was linked to fatalities in Dodoma and Manyara regions [8].

Fumonisins, another group of mycotoxins predominantly found in maize, are neurotoxic, hepatotoxic, and nephrotoxic in humans and animals. They have been classified as possible human carcinogens due to their ability to induce oxidative stress, apoptosis, and alterations in cytokine expression [8]. Other mycotoxins such as ochratoxins, zearalenone, deoxynivalenol, patulin, and ergot alkaloids are also of concern. These toxins affect multiple organ systems, including the liver, kidneys, immune system, and reproductive organs, causing a range of adverse health outcomes [4,9].

The risk of mycotoxin contamination is exacerbated by poor storage and handling practices. Toxigenic fungi thrive in conditions of high humidity and temperature, making improperly ventilated storage facilities and direct contact between grains and moisture-prone surfaces critical risk factors [10]. Studies conducted in Tanzania have highlighted significant levels of aflatoxin contamination during cereal storage, particularly in regions such as Iringa, where suboptimal storage practices prevail [4].

Mitigating the risk of mycotoxin contamination requires a comprehensive approach, including proper storage practices, effective food processing methods, and public education. Storage solutions such as the use of pallets, tarpaulins, and metal silos, along with food processing techniques like sorting, dehulling, and heat treatment, have been shown to reduce mycotoxin levels significantly [11]. However, these practices are not widely adopted in many developing regions due to limited awareness and resources.

This study aims to investigate the prevalence of mycotoxin contamination in cereals and identify associated risk factors within Iringa Municipality, Tanzania. By examining storage practices, levels of community awareness, and the prevalence of mycotoxins, the findings will contribute to developing targeted interventions to improve food safety and reduce health risks in affected populations.

Methods

Study area

The study was conducted in Iringa municipal which is one among the five districts of Iringa Region. The municipal extends between latitude 7º 45´ and 7º 50´ South of equator and longitude 35º 40´ and 35º 45´ East. Iringa municipal has an area of 176 square kilometers with 18 wards namely Kihesa, Mkwawa, Mwangata, Kitwiru, Ruaha, Mtwivila, Ilala, Makorongoni, Mivinjeni, Kitanzini, Mshindo, Gangilonga, Isakalilo, Nduli, Kwakilosa, Igumbilo, Mkimbizi and Mlandege. The estimated total population of Iringa Municipal is 151,345 people, where 71,932 are males and 79,413 females. Iringa urban economy is dependent on agriculture and livestock, industry and commerce, almost 40% of the population of the municipality depends on agriculture and livestock in the fringes of Iringa municipality. About 72,000 hectares out of 162,000 within the municipality are suitable for both agriculture and livestock activities the crops cultivated are maize, beans, potatoes, sorghum, paddy, wheat, sunflower, tea, tomatoes and vegetables. Figure 1 below.

Study design and setting

A cross-sectional study design was carried out at one-time point ohe study was descriptive in form of survey. Usually there is no hypothesis as such, but the aim is to describe a population or subgroup within the population with respect to an outcome and set of risk factors, the purpose of the study was to find prevalence of the outcome of interest, for the population or subgroups within the population at a given time point [11]. A quantitative research approach was used, which emphasized objective measurements and the statistical, mathematical or numerical analysis of data collected through questionnaires and checklist. The approach focused on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon [12].

Figure 1: Iringa Municipality map (Source Google Map).

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Sampling

Multistage sampling method was used to select participants. Sample frame of 18 wards was used to select 4 wards randomly. From each ward that was selected a sampling frame consisting of all streets was used to select 2 streets from each selected ward, in which a total of 8 streets was obtained. From the 8 streets selected, a minimum of 25 respondents was obtained from each street by using both quota and convenience sampling techniques. Quota sampling technique was used to select respondents of a sample characteristic (age), in which the study focused on respondents who are 18 years and above while convenience sampling technique was used to obtain readily available respondents, who were found buying, processing (milling and grinding) or selling cereals at that period of time, until a total of 196 respondents was reached.

Data collection

Objectives were met using two questionnaires and a checklist administered in Iringa Municipality particularly in 4 wards namely Kwakilosa, Mlandege, Kihesa and Ruaha. The first questionnaire assessed general knowledge that respondents have on mycotoxin contamination in cereals and the second questionnaire was used to assess respondents‟ awareness on food processing methods used to reduce mycotoxin contamination in cereals. Lastly, a checklist explored storage facilities and conditions used to store cereals, in which the researcher was able to determine if storage conditions used favor mold growth facilitating mycotoxin contamination in cereals.

Table 1: Social demographic characteristics of respondents.

Characteristics		Number	Percentage
Gender	Male	150	76.5
	Female	46	23.5
Age	18-28	56	28.6
	29-39	71	36.2
	40-50	42	21.4
	51-61	20	10.2
	Above 61	7	3.6
Education Level	Primary	76	38.8
	Secondary	92	46.9
	Tertiary	11	5.6
	No Education	17	8.7
Occupation	Peasant	36	18.4
	Cereal processor	58	29.6
	Cereal retailer	49	25
	Business men	32	16.3
	Unemployed	21	10.7

Data analysis

Data collected from respondents were analysed using Statistical Packages for Social Sciences (SPSS) version 22.0 for quantitative data, which were then presented in graphs, charts and tables.

Results

Social-demographic characteristics of respondents

The study was carried out on risk factors for mycotoxin contamination in cereal in Iringa municipality, it involved a total of 196 respondents in which 156 (76.5%) were male, 46 (23.5%) were female. Majority of respondents 71(36.2%) their age ranged 29-39 years, few being above 61 making up 3.6%. Few respondents 17(8.7%) have no formal education while majority 92(46.9%) have a secondary level education, where by those with higher education level were only 11(5.6%). Iringa is one among the regions that engage highly in agricultural activities, majority of respondents that is 58(29.6%) are cereal processors, cereal retailer being 49(25%) while peasants are 36(18.4%) while minority 21 (10.7%) with no employment. Table 1.

Knowledge on mycotoxin contamination in cereals

The study conducted showed that majority of the respondents that is 171 individuals equivalent to 87.2% did not have knowledge on mycotoxin contamination in cereals, while only 25 individuals equivalent to 12.8% had knowledge on mycotoxin contamination in cereals. However, these findings corroborate those of other studies which reflected high level of ignorance concerning mycotoxin contamination and the fungi that produce them [13].

Among 25 (12.8%) who had knowledge on mycotoxin, 19(76%) were male while 6 (24%) were female. In which majority 11 (44%) with knowledge on mycotoxin contamination in cereal were cereal processors, while 6(24%) were cereal retailer, peasant were 4 (16%) while unemployed were also 4 (16%). The study showed that level of education had negative correlation with mycotoxin knowledge where by ($r = -0.161$, $p < 0.05$).

Table 2: Correlation between Mycotoxin knowledge and Education level.

		Mycotoxin	Education level
		Knowledge	
Kendall's tau_b	Mycotoxin	1	-0.161*
	knowledge		
	Education Level	-0.161*	1

*.Correlation is significant at the 0.05 level (2-tailed).

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Table 3: Gender and Occupation Versus Mycotoxin Knowledge

Mycotoxin Knowledge (Yes)		Number	Percent
Gender	Male	19	76
	Female	6	24
Occupation	Peasant	4	16
	Cereal processor	11	44
	Cereal retailer	6	24
	Unemployed	4	16

Total respondents with mycotoxin knowledge were 25(100%) in which majority of them 13 (52%) did not understand factors contributing to mycotoxin contamination in cereals while 12 (48%) respondents understood the factors, in which majority 8(32%) mentioned poor storage conditions while few 3(12%) and 1(4%) mentioned high moisture content and temperature respectively.

Table 4: Knowledge on factors for mycotoxin contamination in cereals.

Factors for mycotoxin contamination in cereal	Number	Percent
Poor storage conditions	8	32
High moisture content	3	12
Temperature	1	4
Do not know	13	52

Among the 25 respondents with mycotoxin knowledge 12 (48%) knew acute health effects of consumption of mycotoxin contaminated cereals, in which 2 (8%) mentioned blood vomiting, 7 (28%) mentioned blood-diarrhea, 2 (8%) mentioned liver inflammation while 1 (4%) mentioned all 3 of them. The rest 13 (52%) out of 25 (100%) did not have knowledge about the acute health effects.

Chronic health effects of consumption of mycotoxin contaminated cereals include stunted growth, immune system suppression and liver damage or liver cancer. In which 11 (44%) respondents out of 25 (100%) total respondents with knowledge regarding mycotoxin contamination in cereal were aware of long-term health effects of ingestion of mycotoxin contaminated cereals, where by 4 (16%) respondents mentioned stunted growth being the chronic health effect, while 3 (12%), 2(8%), 1 (4%) respondent(s) mentioned liver damage, immune suppression and liver cancer respectively and 1(4%) respondent mentioned all three of them. **Table 5**

Generally, the result obtained corresponds to other studies which showed that a significant number of people in both developed and developing nations are not well informed on contaminants in foods [14].

Table 5: Chronic health effects of consumption of mycotoxin contaminated cereals

Chronic health effects	Number	Percent
Liver cancer	1	4
Immune system suppression	2	8
Stunted growth	4	16
Liver damage	3	12
All the above	1	4
Sub-total	**11**	**44**
Do not know	14	56

Conditions and facilities used to store cereals

Cereal storage is one among risk factors for mycotoxin contamination in cereal, proper cereal storage tends to discourage growth of fungi which in turn reduces risk of mycotoxin contamination. Majority of respondents 143(73%) had an area to store cereal while few of them 53(27%) did not have a storage room.Respondents with cereal storage rooms included peasants 36(25.2%), cereal retailer 49(34.3%) while majority were cereal processors 58 (40.6%). The type of cereal stored included corn 57 (39.9%), rice 51(35.7%) and sunflower 35(24.5%).

Table 6: Storage room Vs Occupation and cereal type.

Cereal storage room		Number	Percent
Occupation	Peasant	36	25.2
	Cereal Processor	58	40.6
	cereal retailer	49	34.3
	Total	143	100
Type of cereal	Rice	51	35.7
	Corn	57	39.9
	Sunflower seeds	35	24.5

General storage conditions

Storage conditions explored included proper ventilation, lighting, presence of proper ceiling and if cereal bags are placed few inches away from the walls. Individual with proper ventilated storage rooms were 62(43.4%) while 81 (56.6%) had no proper ventilated storage rooms. Majority of respondents' cereal bags 87(60.8%) were not placed few inches away from the walls, while few of them 56(39.2%) placed their cereal bags few inches away from the wall. Majority of respondents' storage room 96(67.1%) did not have ceiling while few of them 27 (32.9%) their storage rooms had ceiling. The results of the study obtained corresponded to other surveys conducted by other researchers which showed that majority of individuals piled up bags of cereals on bare floors or leaned them directly against the walls, with majority of them (98.7%)being in unventilated rooms with 1.3% in ventilated rooms [15]. Table 7.

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Table 7: Conditions present during cereal storage.

Criteria for storage conditions		Number	Percent
Ventilation	Proper ventilation	62	43.4
	No proper ventilation	81	56.6
Ceiling	Have ceiling	27	32.9
	No ceiling	96	67.1
	Total	143	100
Cereal bags placed few	Yes	56	39.2
inches away from the	No	87	60.8
walls	Total	143	100

Storage sanitation

Storage sanitation helps to prevent cross contamination from previous stored cereals to present store cereals. Criteria for storage sanitation involved room cleaned before storage of cereal bags, if packaging materials used are cleaned before storage, milling machines are cleaned before processing. Majority of respondent 76(53.1%) do not clean their rooms before cereal storage while 67(46.9%) clean their rooms before cereal storage. Majority 124(86.7%) of packaging materials are cleaned before storage while few of them 19(13.3%) are not cleaned before storage. Total cereal processors were 58(100%), in which 26(44.8%) cereal processors cleaned their milling machines before processing while 32(55.2%) of them did not clean their milling machines before processing.

The results obtained corresponds with other surveys conducted by other researchers which showed that only 3.3% of the feed mills regularly cleaned and sanitized machines (e.g. feed grinder, mixers, storage bins) and surrounding areas while others conducted no cleaning and sanitizing. The poor sanitary practices led to not only feedstuffs built up on the inside walls of machines and facilities, but also packages scattered all over the ground, potentially encouraging fungal growth and cross-contamination [15].

Storage facilities used

Storage facilities include packaging material used, pallets and tarpaulin. Majority (80.4%) of respondents use woven sacks as storage packaging material, while 10.5% use containers while few 9.1% use polyethylene bags. Majority of respondents 111 (77.6%) do not use pallets, hence place their cereals bags on bare floor while only 32(22.4%) respondents use pallets. Respondents with tarpaulin are 67(46.9%) while without tarpaulin are 76 (53.1%).

Awareness on food proccessing methods used to reduce risk of fungi contamination in cereals.

Food processing methods that can reduce levels of mycotoxin contamination include physical, chemical, enzymatic and microbial methods. The study assessed awareness on the physical food processing methods, it included sorting, sieving cleaning, drying and heat methods.

The study showed that 97(49.5%) respondents sort out damaged/spoiled cereals while 99(50.5%) respondents do not sort damaged/spoiled cereals. Among 97 respondents (49.5%) who sort out damaged/spoiled cereals 49(25%) respondents discard after sorting, while 48(24.5%) use as feed. Broken and damaged kernels usually contain most of mycotoxin contamination, sorting technique helps to reduce mycotoxin contamination in cereals hence the unsorted cereals contain high levels of mycotoxin compared the sorted ones.

The study showed that majority of individuals 112 (57.1%) are not aware that sorting of spoiled/damaged cereals reduces

Table 8: Storage facilities.

Storage facilities		Numbers	Percent
Storage packaging materials	Polyethylene bags	13	9.1
	Containers	15	10.5
	Woven sacks	115	80.4
	Total	143	100
Pallets	Present	32	22.4
	Not present	111	77.6
	Total	143	100
Tarpaulin	Present	67	46.9
	Not present	76	53.1
	Total	143	100

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the risk of fungi contamination, while few of respondents 84(42.9%) understand that sorting of damage cereals reduces fungi contamination risk. Majority 117(59.7%) of respondents do not know heat methods that can be used to reduce levels of mycotoxin in cereals while few of them 79(40.3%) mentioned smoking, frying and roasting method as among heat methods that can be used to reduce mycotoxin levels in cereal.

Majority of respondents 109 (55.6%) dry their cereals before further processing or storage while 87(44.4%) of respondents do not dry their cereals. Despite majority dry their cereals, only 80(40.8%) of respondents understand that drying reduces risk of fungi contamination in cereals while the large number of respondents do not understand the significance of drying in relation to fungi or mycotoxin contamination.

Discussion

Knowledge on mycotoxin contamination in cereals

The study carried out showed that majority 87.2% did not have knowledge on mycotoxin contamination in cereals, while only 25 individuals equivalent to 12.8% had knowledge on mycotoxin contamination in cereals, the results obtained corresponds to other studies that shows majority of individuals are not aware of mycotoxins contamination in cereals and the fungi that produces them [13,16,17].

Also other studies which showed that a significant number of people in both developed and developing nations are not well informed on contaminants in foods [18,19]. The study showed that 52% do not know the factors contributing to mycotoxin contamination in cereals, while 32% being the majority mentioned poor storage conditions as one of the risk factors, while other studies showed that moisture as the most mentioned risk factor for fungi contamination in food [16,17].

The results obtained in the study showed that majority 52% and 56% of respondents do not know the acute and chronic health effects of mycotoxin contamination. Other studies also demonstrated a wide knowledge gap amongst those under study where they could not link fungi to mycotoxin contamination and perceived associated health risks [14,17]. It was reported that 82% of parents were not aware of aflatoxin contamination in complementary foods and their health effects [16,17].

Conditions and facilities used to store cereals

The study demonstrated that majority (56.6%) had no proper ventilated storage rooms and many of respondents' cereal bags 87(60.8%) were not placed few inches away from the walls while few of them 27 (32.9%) their storage rooms had ceiling. The results of the study obtained corresponded to other surveys conducted by other researchers which showed that majority of individuals piled up bags of cereals on bare floors or leaned them directly against the walls, with majority of them (98.7%) being in unventilated rooms with 1.3% in ventilated rooms [15].

Majority of respondent 53.1% do not clean their rooms before cereal storage while 86.7% of packaging materials are cleaned before storage. Total cereal processors were 58(100%), in which 32(55.2%) of them did not clean their milling machines before processing. The result also corresponds with other surveys that indicated only 3.3 % of the feed mills regularly cleaned and sanitized machines (e.g. feed grinder, mixers, storage bins) and surrounding areas while others conducted no cleaning and sanitizing. The poor sanitary practices led to not only feedstuffs built up on the inside walls of machines and facilities, but also packages scattered all over the ground, potentially encouraging fungal growth and cross-contamination [15].

Majority (80.4%) of respondents use woven sacks as storage packaging material, while 10.5% use containers while few 9.1% use polyethylene bags. Majority of respondents 111 (77.6%) do not use pallets, hence place their cereals bags on bare floor while only 32 (22.4%) respondents use pallets. Respondents with tarpaulin are 67(46.9%) while without tarpaulin are 76 (53.1%). The results also corresponds to other studies that showed majority used polypropylene woven sacks while few used jute sacks [20-29]. Another study showed 57% store their finished products in polyethylene bags and 20% in leaves for an average of seven days. Fermented foods stored in leaves were more predisposed to fungal and mycotoxin contamination because of the indigenous microflora of the leaves and the deployment of little or no effort to clean or sterilize the leaves before use [14,16,30].

Awareness on food proccessing methods used to reduce risk of fungi contamination in cereals

The study showed that 97(49.5%) respondents sort out damaged/spoiled cereals while 99(50.5%) respondents do not sort damaged/spoiled cereals. Among 97 respondents (49.5%) who sort out damaged/spoiled cereals 49(25%) respondents discard after sorting, while 48(24.5%) use as feed. Broken and damaged kernels usually contain most of mycotoxin contamination, sorting technique helps to reduce mycotoxin contamination in cereals hence the unsorted cereals contain high levels of mycotoxin compared the sorted ones [19,31-33].

The study showed that majority of individuals 112 (57.1%) are not aware that sorting of spoiled/damaged cereals reduces the risk of fungi contamination, while few of respondents 84(42.9%) understand that sorting of damage cereals reduces fungi contamination risk. Majority 117(59.7%) of respondents do not know heat methods that can be used to reduce levels of mycotoxin in cereals while few of them 79(40.3%) mentioned smoking, frying and roasting method as among heat methods

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that can be used to reduce mycotoxin levels in cereal. Roasting can reduce the levels of aflatoxins by 50–70 % in peanuts and pecans and by 40–80 % in maize while methods like frying also reduces mycotoxin levels, while smoking reduces the risk of cereals to be infected by growth of fungi in turn reduces risk of mycotoxin contamination in cereals. In heat method reduction of mycotoxin contamination in food depends on levels of mycotoxins, temperature, time exposed to heat and the type of food heated [20].

Majority of respondents 109 (55.6%) dry their cereals before further processing or storage while 87(44.4%) of respondents do not dry their cereals. Despite majority dry their cereals, only 80(40.8%) of respondents understand that drying reduces risk of fungi contamination in cereals while the large number of respondents do not understand the significance of drying in relation to fungi or mycotoxin contamination. The results obtained corresponds to other studies which showed that a significant number of people in both developed and developing nations are not well informed on contaminants in foods [14,21].

Conclusion

Conclusively, the study assessed risk factors for mycotoxin contamination in cereals in Iringa municipality. In which majority of respondents 171 individuals equivalent to 87.2% did not have knowledge on mycotoxin contamination in cereals, while only 25 individuals equivalent to 12.8% had knowledge on mycotoxin contamination in cereals. While the storage conditions and facilities used, showed that majority of individuals 111(77.6%) piled up bags of cereals on bare floors (no pallets) and 87(60.8%) leaned them directly against the walls with majority of them 96(67.1%) placed under roofs with no ceiling. Food processing method that majority 109(55.6%) performed was drying of cereals before further processing or storage, despite majority dry their cereals only 80(40.8%) of respondents understand that drying reduces risk of fungi contamination in cereals while the large number of respondents 116(59.2%) do not understand the significance of drying in relation to reduction in risk of fungi contamination.

Recommendations

I. Intervention should be taken to raise awareness regarding mycotoxin contamination in cereals, as majority 87.2% do not have knowledge concerning mycotoxin contamination.

II. Use of pallets to place cereal bags away from the ground, as majority 77.6% do not have pallets. Cereal packaging materials, such as woven sack can be made hermetic by tightly folding and stitching the sack to prevent attraction of fungi and other insects, should be placed under roofs with ceiling to be able to control temperature of the storage room and prevent entry of water during rain.

III. Facilities should be cleaned before storage or usage, as majority 55.2% do not clean their milling machines before processing, leads to feedstuffs building up on the inside walls of machines and facilities, but also packages scattered all over the ground, potentially encouraging fungal growth and cross-contamination as majority 53.1% do not clean their storages.

Abbreviations

- AFB1 - Aflatoxin B1
- AFB2 - Aflatoxin B2
- AFG1 - Aflatoxin G1
- AFG2 - Aflatoxin G1
- BGYF - Bright Greenish-Yellow Fluorescence
- CAC - Codex Alimentarius Commission
- CIT - Citrinin
- DAS - Diacetoxyscir- penol
- DON - Deoxynivalenol Et. al - And Others
- FAO - Food and Agriculture Organisation
- FB1 - Fumonisins B1
- FB2 - Fumonisins B2
- GAP - Good Agriculture Practices
- GMP - Good Manufacturing Practices
- HBV - Hepatitis B virus
- IARC - International Agency for Research on Cancer
- JECFA - Joint FAO/WHO Expert Committee on Food Additives
- NIV - Nivalenol OTA - Ochratoxin A
- TFDA - Tanzania Food, Drugs and cosmetics Authority
- USDA - United States Department of Agriculture
- WFP - World Food Programme
- WHO - World Health Organization
- ZEN – Zearalenone

Declaration

Ethics

Approval and Consent Participation The study was approved by Ruaha University and Iringa Municipality, Tanzania. All respondents were informed about the nature of the study, refusal to answer to any question that they deemed sensitive, the data collection procedures and confidentiality. The Data collection methods used in this study were in accordance to ethical standards and human rights. Both verbal and written informed consent was obtained before administering questionnaires and checklist.

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To ensure privacy and anonymity names were not included on Questionnaires, while names of facilities where checklist was used confidentiality was observed.

Consent for Publication: Not applicable.

Availability of Data and Materials

The dataset is with the corresponding author, available upon request.

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Authors' Contribution

RAR wrote the research proposal and analysed the data. P M C the manuscript and R M did the technical check of the work. All authors approved the final draft of the Manuscript. Acknowledgement We would like to express our special thanks to the Department of Environmental Health Sciences in RUCU for their valuable contributions, assistance and useful comments

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