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Smallholder farmers' storage practices and awareness on aflatoxin contamination of cereals and oilseeds in Chamwino, Dodoma, Tanzania

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Agricultural produces in the tropics are vulnerable to mycotoxins contamination. Hot and humid conditions are favourable conditions for fungal growth and production of mycotoxins. Inadequate drying and storage practices aggravate the susceptibility of produce to mycotoxins contamination. The purpose of this study was to assess the storage practices and awareness of smallholder farmers on mycotoxin contamination of cereals and oilseeds in Chamwino district, Dodoma region. A total of 90 smallholder farmers were interviewed using a structured questionnaire containing closed-ended questions. Smallholder farmers kept their produces on the bare ground during harvesting (42%), used open-sun drying (92%) and rudimentary method to check produce dryness (72% visual assessment and 9% biting), and stored grains in plastics or woven bags which are placed on the floor without pallets (95.6%). Moreover, the majority have neither heard about mycotoxins (88.9%) nor aware on fungal contamination and effects of consuming mycotoxins contaminated products (81.1%). Unfortunately, the overwhelming majority (96.7%) of smallholder farmers involved in this study were not aware that feeding animals with aflatoxins contaminated feeds lead to contaminated animal/poultry products. This indicates that consumers are exposed to products which are most likely contaminated with mycotoxins. Training of farmers and mass media campaigns are highly recommended to reduce post-harvest losses and mycotoxin contamination along the produces value chains.

Key words: Aflatoxins, storage practices, awareness, smallholder farmers.

INTRODUCTION

Agriculture is the mainstay of Tanzania's economy. It employs more than 65.7% of the population and contributes 26.7% of the Gross Domestic Product (GDP). Majority of farmers are smallholder farmers (80%) with less than one acre of land (Mkonda and He, 2018) producing food and/or cash crops. Major food crops are maize (6.3 million MT), cassava (2.8 million MT), paddy (2.2 million MT), beans/legumes (1.8 million MT), sweet potatoes (1.6 million MT), banana (1.1 million MT), sorghum (0.988 million MT) and wheat (0.057 million MT) (MoFP, 2018). The major cash crops include cashew nuts (313.8 million MT), sugar (303.7 million MT), cotton

(222.0 million MT), tobacco (50.5 million MT), coffee (45.2 million MT), sisal (40.6 million MT), tea (34.0 million MT) and pyrethrum (2.4 million MT). The major oilseeds include sunflower (768.2 million MT), groundnuts (643.5 million MT) and sesame (133.7 million MT) (MoFP, 2018).

Cereal productivity per acre in Africa, Tanzania inclusive, is (1.8 MT/ha) less than half of the world average (~5 MT/ha). Despite the low productivity, Africa experiences high (30-40%) post-harvest losses of cereals and oilseeds due to inadequate pre-and post-harvest management (Suleiman and Kurt, 2015; Kumar and Kalita, 2017). Poor post-harvest management techniques (including inadequate drying and storage) of the produces are the major contributing factors (Suleiman et al., 2017). Food losses start from the field throughout the value chain to the end-users (that is, farm to fork). Thus at different nodes (e.g., harvesting, threshing, drying, transportation, processing, storage, distribution and consumption) of the food value chain losses are inevitable. Inadequate drying, pest infestation, fungal attack, and limited knowledge on best handling practices are the major contributing factors to high Post-Harvest Losses (PHLs).

Smallholder farmers in the developing countries practice subsistence farming. They mainly produce for their food uses, and very little surplus is sold for cash. A big proportion of their produces is therefore stored for food until the next harvesting season. However, the majority of smallholder farmers are financially challenged to construct proper storage facilities and have limited knowledge on post-harvest management practices (Muroyiwa et al., 2020). During harvesting and drying, cereals and oilseeds are often heaped on the bare ground. Sundrying is a common method used for drying agricultural produces in the tropics (Likhayo et al., 2018). Although the method has been used from the ancient times, it has several limitations like inadequate drying, contamination, losses, and pest infestation (Suleiman et al., 2017; Mobolade et al., 2019).

Traditional storage techniques (e.g. uncovered wooden granaries, plastic/polyethylene bags) which have proved to be inadequate are the primary means of storage practised by most small-scale farmers in Tanzania. As a consequence, PHLs of cereal grains during storage are estimated to range from 15 to 25% (Mesterházy et al., 2020). The technical assistance including a public financing for adequate grains storage to smallholder farmers depends on the available new storage technology and whether they are cost effective within the local context (Kotu et al., 2019). Mould growth on stored produces dependent on grain moisture content, temperature, gas composition, relative humidity (RH), and fungal contamination during harvesting and storage (Manandhar et al., 2018). Thus, inadequate drying and poor storage conditions aggravate the problem of PHLs.
Unfortunately, mould growth may result into production of secondary metabolites, the mycotoxins. Aflatoxins are the most toxic group of mycotoxins produced by fungal species, *Aspergillus flavus* and *Aspergillus parasiticus*, which commonly infect food crops such as maize, peanuts, sunflower seeds and tree nuts (Kamala et al., 2015; Mmongoyo et al., 2017). Consumption of aflatoxin-contaminated foods and feeds is linked to various adverse health effects like liver cancer in humans and low productivity in animals (Magembe et al., 2016; Benkerroum, 2020).

Good agricultural and post-harvest handling practices (GAP and GPHP) have been recommended as appropriate approaches for reducing both PHLs and aflatoxins contamination of agro-produce (Kumar and Kalita, 2017; Phokane et al., 2019). Limited knowledge on GAP and GPHP by smallholder farmers in Tanzania, exposes agro-produce to aflatoxins contamination during the pre and post-harvesting stages (Magembe et al., 2016; Ayo et al., 2018; Nakavuma et al., 2020). Training and dissemination of information on GAP and GPHP are important strategies to reduce PHLs and aflatoxins contamination of agro-produces along their respective value chains. Therefore, this study aimed at assessing the knowledge, awareness of aflatoxins and storage practices of maize, groundnuts and sunflower seeds by smallholder farmers in Chamwino district, Dodoma region, Tanzania.

MATERIALS AND METHODS

Study location

The study was conducted in November 2019 in Chamwino district. Chamwino district is among the seven districts in Dodoma region; it is located below the equator between latitude 6° and 10ʹ south and between longitude 35° 46’ east. The total population of Chamwino district is approximately 330,543 people (NBS, 2012).

The district is considered amongst the areas with high food insecurity and mycotoxins contamination (Suleiman et al., 2017). Three villages (Haneti, Mapanga and Zajilwa) from three wards (Haneti, Itiso and Zajilwa) were involved in this study.

Study design

A cross-sectional survey approach was used to collect data from smallholder farmers producing maize, groundnuts and sunflower seeds. The farmers were randomly selected from three villages at

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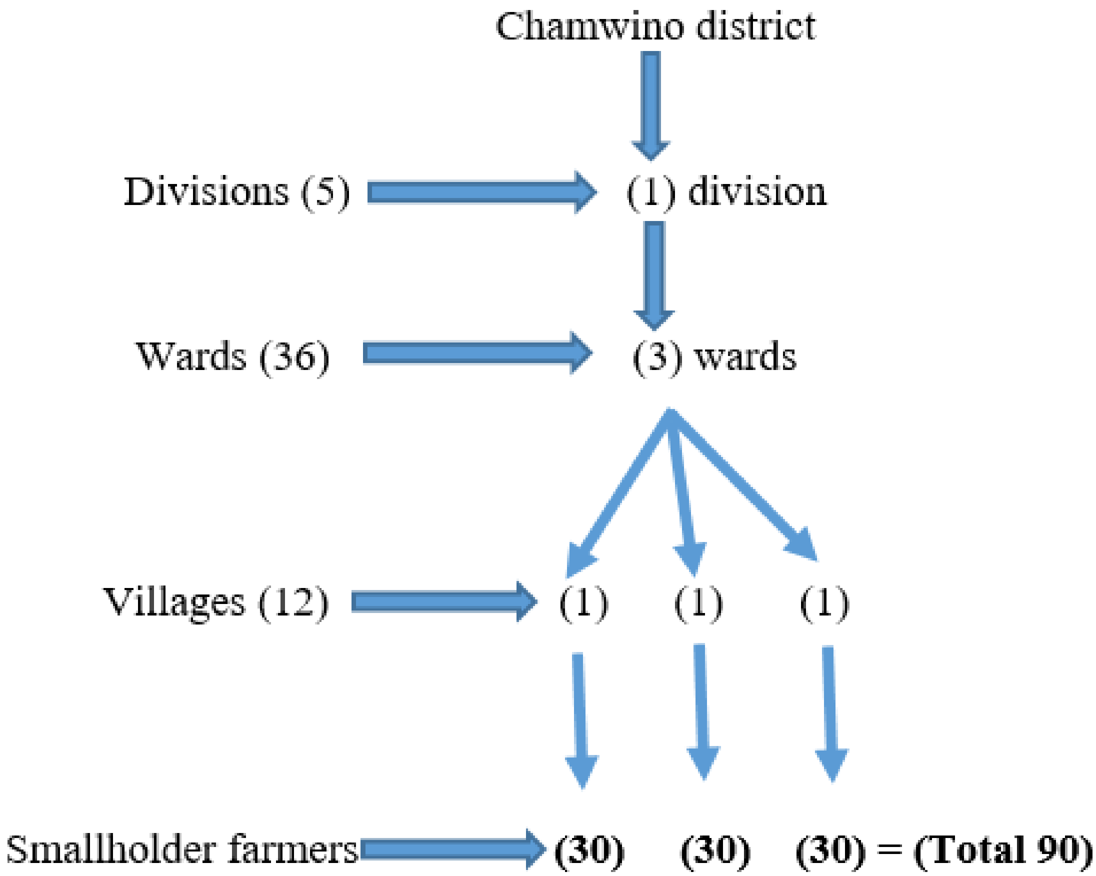

Figure 1. Sampling plan of smallholder farmers from villages of Haneti, Zajilwa and Mapanga in Chamwino district.

Chamwino district. This design was used to collect data on smallholder farmer's knowledge, storage practices and awareness of aflatoxins-contamination of maize, groundnuts and sunflower seeds.

Sampling procedure

Multi stage sampling design was adopted in this study (Acharya et al., 2013). In summary, one division (Itiso) was purposively selected among the five divisions of Chamwino district. Three wards, namely, Haneti, Zajilwa and Itiso were also purposively selected based on the production rate of maize, groundnuts and sunflower seeds as advised by the District Agriculture Irrigation and Cooperative Officer (DAICO). Then, one village was randomly selected from each of the chosen wards, as indicated in the sampling plan (Figure 1). Finally, 30 households which store all three crops (maize, groundnuts and sunflower seeds) were randomly selected from each village (n=90).

Assessment of knowledge, storage practices and awareness of aflatoxin contamination of smallholder farmers

Aquestionnaire containing both closed-ended questions was used to collect data. The questionnaire was designed for smallholder farmers producing maize, groundnuts and sunflower seeds. It contained 40 questions on knowledge, storage practices and awareness of aflatoxins contamination of maize, groundnuts and sunflower seeds. The questionnaire was translated to Swahili and pre-tested using maize traders (n = 15) picked randomly in Dar es Salaam. After pre-testing, the questionnaire was modified and properly coded.

Statistical data analysis

Data collected were summarized and analyzed using Statistical Package for the Social Sciences software (IBM SPSS® Version 20, Chicago, IL, USA). Descriptive statistics were carried out to obtain frequencies, means and percentages among the variables. The results are presented in tables, graphs and charts.

RESULTS AND DISCUSSION

Demographic characteristics of smallholder farmers

The majority of smallholder farmers interviewed were males (57.8%), aged more than 56 years (35.6%), married (82.2%) and lowly educated (75.6% had primary education and 15.6% had no informal education, Table

Table 1. Demographic characteristics of smallholder farmers (N=90).

Variable	Description	Villages			Total
		Haneti	Zajilwa	Mapanga	
Gender	Male	26.9	36.5	36.5	57.8
	Female	42.1	28.9	28.9	42.2
Age	15-25	0.0	3.3	0.0	1.1
	26-35	3.3	30.0	20.0	17.8
	36-45	13.3	30.0	36.7	26.7
	46-55	23.3	13.3	20.0	18.9
	56+	60.0	23.3	23.3	35.6
Education level	Primary school	80.0	76.7	70.0	75.6
	Secondary school	10.0	16.7	0.0	8.9
	Informal education	10.0	6.7	30.0	15.6
Marital Status	Married	76.7	90.0	80.0	82.2
	Not married	16.7	10.0	10.0	12.2
	Divorced	0.0	0.0	10.0	3.3
	Widow	6.7	0.0	0.0	2.2
Training on good agricultural practices	Yes	43.3	16.7	16.7	25.6
	No	56.7	83.3	83.3	74.4

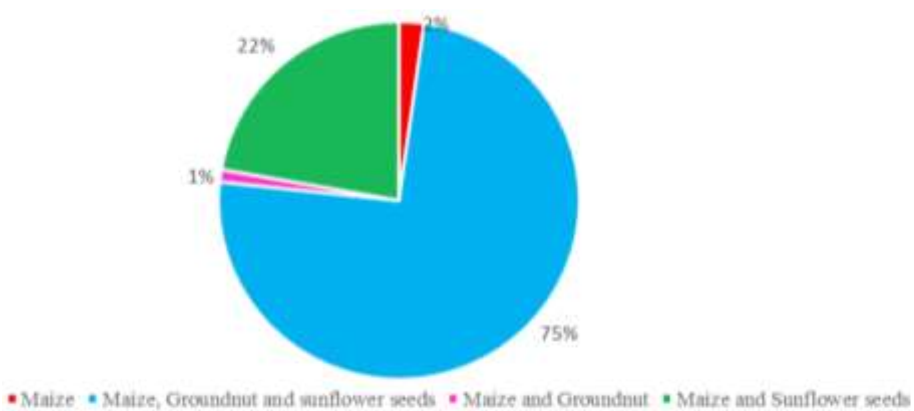

Figure 2. Types of Cropping systems in Chamwino.

1). Previous studies also found that smallholder farmers are people with low or informal (11%) level of education (Adekoya et al., 2017) and the farming acitivty is male dominated (57.7%) (Toma, 2019). However, in the rural areas women are the ones mainly involved with farming activities as compared to males. Most of the households were male headed and were the ones participated in the interview. The study also revealed that 74.4% of smallholder farmers had never attended any training on GAP (Table 1). Combination of these aspects may increase PHLs and aflatoxins contamination. Training of smallholder farmers on GAP is critically important to reduce PHLs and aflatoxin contamination along the produces value chains (Stepman, 2018).

Cropping system practised by the smallholder farmers

Ninety-eight (98%) of the interviewed smallholder farmers at Chamwino practised multicropping (Figure 2). Out of this, 75% intercropped maize, groundnuts and sunflower

Table 2. Acreage and annual production (tones) of maize, groundnuts and sunflower seed.

Village	Production (tones) 2018/2019		
	Maize	**Groundnuts**	**Sunflower**
Haneti	8937	127	7149
Zajilwa	518	53	1510
Mapanga	155	10	53
Average (production)	3,203	63	2,904
Acreage	9.0±4.58	8.5±4.98	1.6±1.34

seeds, 22% intercropped maize and sunflower seeds, whereas 1% intercropped maize and groundnuts (Figure 2). The average farm sizes were 9.0±4.58 ha for maize, 8.5±4.98 ha for sunflower, and 1.6±1.34 ha for groundnuts (Table 2). Likewise, previous studies observed mixed farming system in Dodoma (Mlay et al., 2017).

The annual production of maize, sunflower seeds and groundnuts for 2018/2019 are presented in Table 2. On average, maize had higher production (3,203 tones) followed by sunflower seeds (2,904 tones) and lastly groundnuts (53 tones) (Table 2). Haneti had significantly higher maize and sunflower production (8937 and 7149 tones) than Mapanga (155 and 53 tones) (Table 2). The low productivity for groundnuts could be contributed by seed recycling practised by the smallholder farmers.

Post-harvest handling and storage practices

Post-harvest handling and storage practices of agricultural produces involve various processes including but not limited to drying, cleaning, transportation and storage.

Drying

The study revealed that sun drying is the major method practised by the majority of smallholder farmers (92.2%) to dry maize, groundnuts and sunflower seeds by either leaving matured crops in the field for several weeks (64.1%) or harvesting and drying on the bare ground (42.2%) (Table 3). Sun drying is a traditional drying method of crops practised in the tropical countries (Kumar and Kalita, 2017). Similar drying practices have been reported in Malawi (Matumba et al., 2016) and Kenya (Koskei et al., 2020). However, drying practices like leaving crops in the field and drying on bare grounds could increase the chance for fungal growth, aflatoxins and sand contamination (Negash, 2018).

Moreover, 17.8% of the interviewed smallholder farmers physically checked grains for dryness. However, none of them had moisture meter to correctly assess moisture content of the grains. They used traditional practice of chewing grains to determine whether the grains are dried properly (Table 3). This practice may not provide the correct moisture content of grains; grains thought to be dry could be wet to develop fungal growth and mycotoxin production on storage. Previous studies have observed the same practice in assessing grains dryness (Magembe et al., 2016). More than 58% of smallholder farmers shelled/threshed their produces manually on farms by beating and/or striking (Table 3). During manual threshing grains, spillage and breakage can occur due to excessive striking or beating, resulting in grain losses. Ali and Khalid (2015) found that manual and mechanical threshing causes 1.12 and 1.09% grain losses, respectively. On the contrary, Abass et al. (2014) reported higher manual threshing losses for maize (13.4%), groundnuts (18.0%) and sunflower seeds (20.0%). Use of mechanical thresher could significantly reduce grain losses.

Cleaning

The smallholder farmers did not clean nor sort grains (31.1%) (Table 3), and this may increase predisposition of stored produce to aflatoxins contamination. In postharvest handling of agro-produce, cleaning is very important operation as it serves to remove all physical objects such as stones, sands and to separate whole infected or broken grains. Inadequate cleaning of grains can contribute to insect infestation, poor quality product including adverse health effect to human (Kumar et al., 2017). Also, it increases maintenance costs for milling machine as physical objects may cause damage. Consumption of grains with higher percentage of discoloration is a potential risk to exposure to mycotoxins like aflatoxins (Likhayo et al., 2018). In some cases a very limited cleaning is done through winnowing or use of strainers. This calls for the need of centralized drying, cleaning and storage facilities in rural areas to ensure proper and standardized postharvest handling of cereals and other produce in a view to ensure food safety and competitive market access. It is therefore, vitally important that dirt and impurities be removed as soon as possible to delay the deterioration process and ensure that the product being stored is of high quality for end

Table 3. Frequency distribution of smallholder farmers according to postharvest handling and storage practices of stored grains.

Variable	Description	Frequency (N=90)	Percentage
Method to dry	Sun drying	83	92.2
	Air drying	7	7.8
Drying time	Maize < 7 days	10	11.1
	Maize above 8 days	80	88.9
	Groundnuts < 7 days	21	23.3
	Groundnuts above 8 days	46	51.1
	Not dry groundnuts	23	25.6
	Sunflower seeds < 7 days	40	44.4
	Sunflower seeds above 8 days	47	52.2
	Not dry sunflower seeds	3	3.3
Shelling/Threshing methods	Hand shelling	52	57.8
	Motorised thresher	38	42.2
Where do you kept produces during harvesting?	Bare ground	38	42.2
	Raised platforms	7	7.8
	Tarpaulin	18	20.0
	Jute/Sisal bags	7	7.8
	Plastic/synthetic bags	20	22.2
Well dried	Measure moisture content	16	17.8
	Bite the grains	8	8.9
	Visual assessment	65	72.2
	sound	1	1.1
What action did you take if it rains and produces are at open space?	Cover	61	67.8
	Take to the protected area	17	18.9
	Not cover	9	10.0
	Not rain	3	3.3
Sort/Clean grains	Sort	62	68.9
	Not sort	28	31.1
How do you sort grains?	Colour	28	31.1
	Damage	33	36.7
	Colour and damage	1	1.1
Which storage facility did you use?	Jute/Sisal bags	4	4.4
	Plastic/Synthetic bags	86	95.6
Storage management	Cleaning	56	62.2
	Fumigation	8	8.9
	Cleaning and fumigation	23	25.6
	No cleaning	3	3.3
Where do you store your produces?	Warehouse	30	33.3
	Under the shed	16	17.8
	In living house	44	48.9

Table 3. Contd.

Storage time	Maize < 6 months	73	81.1
	Maize above 7 months	17	18.8
	Groundnuts < 6 months	54	60.0
	Groundnuts above 7 months	15	16.7
	Not store groundnuts	21	23.3
	Sunflower seeds < 6 months	73	81.1
	Sunflower seeds above 7 months	14	15.6
	Not store sunflower seeds	3	3.3
Use of pesticides duringstorage	Yes	66	73.3
	No	24	26.7
Use of pesticides treated seeds	Yes	41	45.6
	No	49	54.4

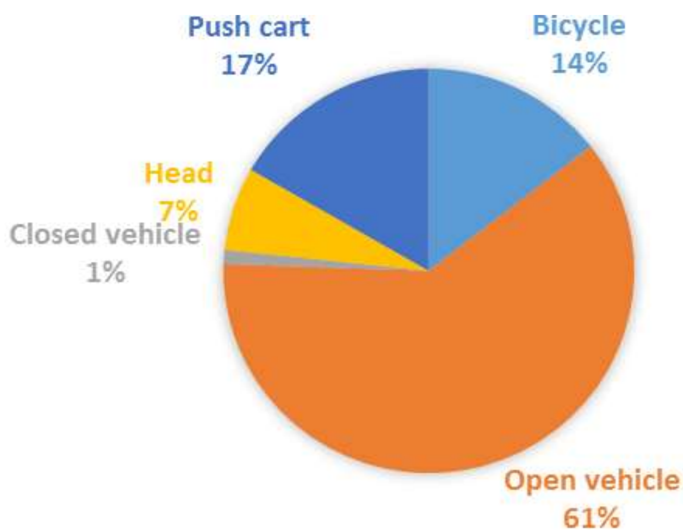

Figure 3. Type of produce transport used by smallholder farmers at Chamwino.

user. In a nutshell, pre-cleaning of grain before storage adds value to the grain through removal of dirt, impurities and damaged particles; and ensures a long life of grain in storage. Clean grain will fetch a better price than dirty grain.

Transportation and storage

Transportation is among the post-harvest practices applied by smallholder farmers along the value chains which involve the movement of agricultural produces from one step to another; for example, from field to storage facilities or market place. The primary transportation means of harvested crops are however, by open vehicles (61%) and pushcarts (17%) (Figure 3). Open vehicles and pushcarts could expose the produce to rains and fungal spores contamination. Poor infrastructure in rural setting accompanied with inadequate handling practices increase the possibilities of contamination and high PHLs (Kumar et al., 2017; Manandhar et al., 2018).

Grains storage structure should be well ventilated and bags must be placed on treated pallets, and allow free space of about 25% (for movement of people and material). With respect to packaging, the grain is stored on platforms in heaps, in woven baskets or bags. There are also hermetically sealed bags recommended for long term storage (Manandhar et al., 2018). Thoroughly cleaning of grain prior to storage and regular fumigation of store is vital.

In the surveyed areas, basic storage-structures for grain storage are minimal. For instance, in some villages,

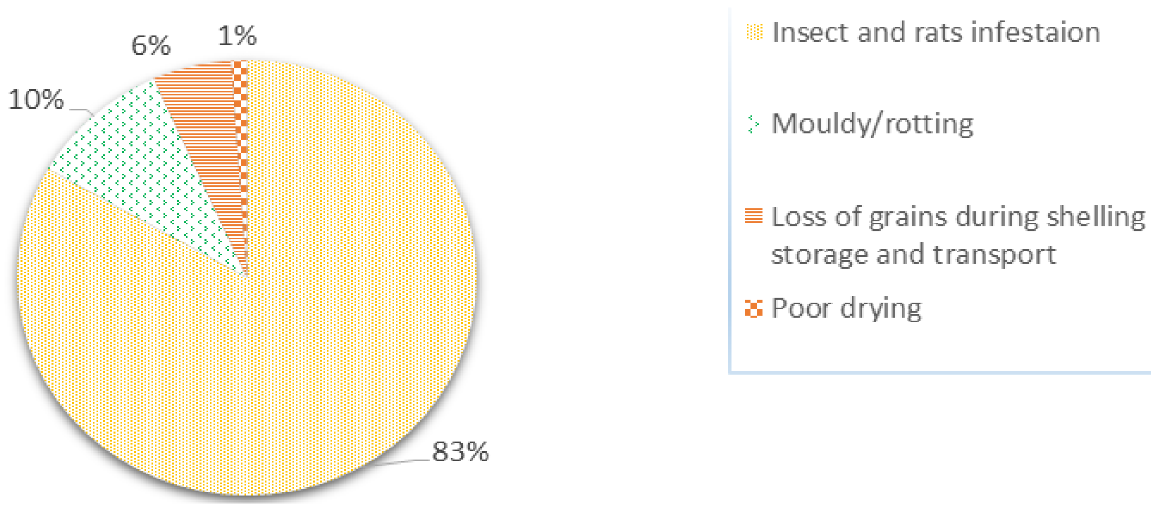

Figure 4. Grain losses encountered by interviewed smallholder farmers at Chamwino.

grains packed in polyethylene bags were found stored in small, poorly ventilated houses or just placed on the floor without pallets. Furthermore, the bags in the stores were poorly arranged worsening air circulation. Poorly ventilated rooms, with poorly arranged bags coupled with uncleaned grains may lead to collection of moisture, high temperature and humidity which are favourable conditions for mould growth and consequently mycotoxins contamination of stored grains. Previous studies have reported high temperature, relative humidity and moisture as major factors to monitor in storage room (Waliyar et al., 2015; Neme and Mohammed, 2017). It was also noted that 48.9% of smallholder farmers stored grains in their living house (Table 3). The storage areas had vents without nets/screens to prevent entrance of pests like insects and rats. Unlike the result reported in Eastern region of Kenya that 55.6% of farmers store harvested grains inside their living house (Njoroge et al., 2019).

This study observed that stores or houses are poorly designed and often made of mud; the walls have chunk and chinks with mud floors which may allow the entrance of pests. Traditional storage structures protect grains from rains and sun, but air and moisture can pass through that and can result to pest infestation of stored grain (Manandhar et al., 2018). These scenarios coupled with high temperature and humidity levels especially in the tropics contribute to high (20-40%) post-harvest losses (Wild et al., 2015). This study revealed that 18.8, 16.7 and 15.6% of smallholder farmers stored maize, groundnuts and sunflower seeds, respectively for longer than seven months (Table 3). Storage of grains for such long period under in-appropriate conditions may aggravate spoilage and mycotoxin contamination. Previous studies have reported aflatoxin contamination on grains stored for less than six months due to inadequate post-harvest management practices (Mohamed, 2017).

About 3.3% of smallholder farmers did not clean their stores when storing new harvest (Table 3), which exposes the produce to aflatoxin contamination. The study by Kamala et al. (2016) reported that, farmers clean their storage facility to ensure no mixing of previous harvest and newly harvested ones. Figure 4 shows that 83% of smallholder farmers encounter losses of agricultural produces due to insect and rat infestation. Previous studies in the same district observed majority of farmers (60%) experiencing maize losses due to pest infestation (Suleiman et al., 2017). However, minimal losses are likely when storage is done in clean facility and grains are dried properly (Mwangi et al., 2017). The higher losses of grains observed in this study was attributed to poor building structures including storage facilities such as polyethylene bags which allow contamination of stored grains.

This study found that 73.3% of smallholder farmers applied pesticides to stored grains (Table 3). However, few farmers (33%) in Kongwa district use pesticides during storage of maize (Seetha et al., 2017). Moreless, the same level (71%) of farmers in Kenya use pesticides to control pests during grain storage (Koskei et al., 2020). Although use of pesticides is common to smallholder farmers, majority have no skills on proper use of the pesticides. Yet, they may either use single pesticides or coctions of pesticides. The common pesticides applied by majority of farmers assessed in this study include actellic, permethrin and aluminium phosphide (phosphine). Kumar and Kalita (2017) stated that the most common pesticides applied by farmers in developing countries include permethrin, actellic and phosphine. However, the use of actellic super which is the mixture of actellic and permethrin for grain storage stored in polypropylene bags help to fight against pest infestation for few months of storage (De Groote et al., 2013).

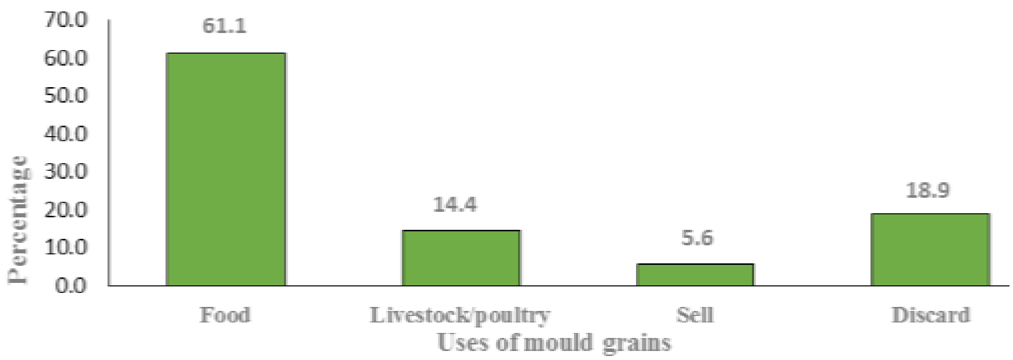

Figure 5. Use of rotten or mouldy grains by the interviewed smallholder farmers.

Table 4. Smallholder farmers knowledge and awareness of mycotoxins contamination.

Variable	Description	Frequency (N=90)	Percentage
Do you know what fungi are?	Yes	42	46.7
	No	48	53.3
Have you ever observed mouldy grains?	Yes	74	82.2
	No	16	17.8
Are you aware that fungi contamination cause health problem?	Aware	17	18.9
	Not aware	73	81.1
Has any member of your family gotten ill following consumption of mouldy food?	Yes	9	10.0
	No	81	90.0
Do you know that fungi produce toxins?	Yes	12	13.3
	No	78	86.7
Have you ever heard the word mycotoxins?	Yes	10	11.1
	No	80	88.9
Are you aware that feeding animals with aflatoxin-contaminated feeds contaminate animal/poultry products?	Aware	3	3.3
	Not aware	87	96.7

Smallholder farmers knowledge and awareness on mycotoxins

The awareness on mycotoxins by smallholder farmers in Chamwino is very low. More than 60% of interviewed farmers used fungal contaminated or rotten produce for food or diverted use to animal feeds (14.4%) (Figure 5). This implies high potential health risk for most families in the rural areas being exposed to aflatoxicosis. Likewise groundnut farmers (41%, n = 805) in Malawi consumed spoiled groundnuts (Matumba et al., 2016). Previous studies observed use of rotten grains in preparation of animal feeds (Mboya and Kolanisi, 2014; Magembe et al., 2016).

More than half (53.3%) of smallholder famers did not knew about fungi; however, 82.2% indicated that their grains got mouldy and 81.1% were not aware that fungi contamination may cause health problems (Table 4). Similarly, a study conducted in Uganda reported that, 88.6% (n=44) of the respondents encountered moulds in grains and feeds during storage (Nakavuma et al., 2020). Another study in Vietnam found that ≥50% (n=551) of the respondents indicated that cereals get mould (Lee et al., 2017).

Moreover, 96.7% of interviewed farmers were not aware that feeding animals with mycotoxin contaminated maize could contaminate milk with a mycotoxin, particularly aflatoxin (Table 4). A different study conducted in Kilosa Tanzania found that 66.7% (n=72) of the respondents were not aware of health hazards caused by mycotoxins (Magembe et al., 2016). Also, Matumba et al. (2015) reported a lack of awareness on health effects caused by mould and mycotoxins among the smallholder farmers in Malawi. The difference in the level of awareness can be attributed to the nature of the study population. In general, people from remote areas have low education level and less opportunity to access information on mycotoxins as compared to those in urban areas.

About 10% of interviewed smallholder farmers had experienced aflatoxicosis cases due to consumption of mouldy food (Table 4). For instance, in 2016 Tanzania experienced aflatoxicosis outbreak in Dodoma region. A rapid epidemiological survey was conducted in the affected villages, which reported a total of 68 cases of affected persons with 20 scores of death due to consumption of aflatoxin (2.4-285 µg/kg) contaminated maize (Kamala et al., 2018). Surprisingly, this event did not increase the awareness of the farmers on mycotoxins; as most farmers are not aware and could still consume mouldy grains.

CONCLUSIONS AND RECOMMENDATIONS

In general, smallholder farmers at Chamwino district in Dodoma have low level of knowledge on the good postharvest handling practices. Limited knowledge (mouldy grains for food or diverting them to animal feeds) and equipment to properly dry and store agricultural produces increases the risks of aflatoxin contamination along the produce value chains. Since aflatoxins are hardly decontaminated once they get access to foods, intervention measures are needed at nodes where they are regarded as hot spots for contamination. Unlike, food products in commercial chains, household-stored maize are consumed by members of such household. Unfortunately, rural households are limited with meal diversification which exacerbates the risks. From the observation made in this study, in order to ensure food safety, improve rural livelihood and the contribution of agriculture to the economy it is recommended that the government assists smallholders to form farmers groups specifically for cereals and other produce such as beans, groundnuts, sunflower, etc.

The Cereals and Other Produce Board of Tanzania could coordinate other stakeholders along the produce value chains. The regulatory organs such as Tanzania Bureau of Standards should design and implement a mass awareness campaign (including school children) on mycotoxins contamination of food and its health and economic consequences. However, further studies are recommended to explore, establish and implement real time techniques for the control of mycotoxins along the entire agricultural value chain in Dodoma region.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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