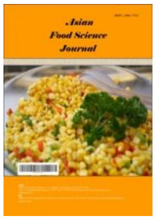

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Postharvest Handling Knowledge and Practices among Food Handlers on Mycotoxigenic Molds Contamination in Maize Based Diets in School Meals Program in Salima District, Malawi

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Authors' contributions

All authors contributed intensively to this work. Author GMJ Conceptualization, writing original draft. Authors GOA, LGN and KM Reviewing and editing. Author DGO Data analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of the present study was to determine the postharvest handling knowledge and practices among food handlers on mycotoxigenic molds contamination in maize based diets in School Meals Program in Salima District, Malawi.
Study Design: This was cross-sectional study with qualitative and quantitative component.
Place and Duration of Study: The study was carried out in Salima district, Central Malawi, between August and November, 2019.
Methodology: The study used a structured questionnaire which was administered to 124 individual food handlers which were purposively selected from 31 primary schools. The simple random sampling technique was used to select the 31 primary schools among those implementing

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home-grown school meals program. The food handlers included School Meals Cooks, Food Suppliers, Food Committee members, and Stores Keepers. Data was analyzed using Statistical Package for Social Scientists (version 20.0).
Results: The results showed that 80% of food handlers had high knowledge of causes of mycotoxigenic molds contamination in maize foods, 47% had moderate knowledge of health effects of mycotoxigenic molds, while 50% had moderate knowledge of control measures of mycotoxigenic molds in maize foods. Eighty-five percent (85%) were not aware of mycotoxins contamination in maize foods. Furthermore, the study revealed that 60% of food handlers practiced poor postharvest handling of maize foods during transporting, storage and processing in schools. There were no significant differences in knowledge of mycotoxigenic molds and postharvest handling practices of maize foods across demographic regions among food handlers (P >0.05).
Conclusion: The study concluded that majority of food handlers had high knowledge of mycotoxigenic molds in maize foods, however they practiced poor postharvest handling which might influence occurrence of mycotoxigenic molds in maize based diets for school children. There is need to educate all stakeholders involved in School meals Programme on mycotoxins and postharvest handling of maize foods to prevent school children from the risk of mycotoxins exposure.

Keywords: Mycotoxigenic-molds; maize-based-diets; mycotoxins; food-handlers; postharvest handling.

1. INTRODUCTION

School Meals Program (SMP) is one of the social safety net programs that aim at alleviating hunger while promoting education, health and community development. There are different types of the SMP which include provision of school meals during learning hours or distribution of home food rations to pupils Food and Agriculture Organization (FAO) and World Food Programme (WFP) [1]. According to World Food Programme [2], approximately 368 million children in low and middle income countries are fed school meals under SMP which are supported by governments and development partners, of which 954,669 Primary school children are from Malawi.

The School Meals Program in Malawi include provision of porridge of Corn-Soya Blend (CSB), Take Home Rations (THRs) of maize to orphan children, and Home-grown school meals program (HGSMP) in which a variety of foods were sourced locally and prepared for learners at school WFP [2]. Maize is one of the staple food and ingredient in Home-grown school meals program.

Major staple foods such as maize are however prone to mycotoxins contamination which are commonly produced by natural occurring mycotoxigenic molds species such as *Aspergillus flavus, Aspergillus parasiticus, Fusarium Verticilliodes and Fusarium proliferatum. Aspergillus flavus* produces aflatoxin B_1 and aflatoxin B_2, while *Aspergillus parasiticus* includes aflatoxin G_1 and aflatoxin G_2 which commonly contaminated products such as maize and nuts World Health Organisation (WHO) [3]. Fumonisins are similar to aflatoxins, produced naturally by toxic molds *Fusarium verticilliodes* and *Fusarium proliferatum. Fusarium verticillioides* species was recognized as the most virulent contaminant of both human food and animal feeds Horn [4].

Chronic co-exposure to aflatoxin and fumonisins have been associated with various health effects such as liver cancer, esophageal cancer, immunosuppression, impaired child growth, mutagens and death in case of high toxin intake levels Gong et al. [5], Kowalska et al. [6], Sun et al. [7]. Aflatoxin B_1 and Fumonisin B_1 have been reported as the most carcinogenic in human being International Agency for Research on Cancer (IARC) [8].

Study reports have shown that lack of knowledge and poor postharvest handling practices of maize foods, contributes to aflatoxins and fumonisins production Eshiett et al. [9]. Inadequate knowledge on mycotoxigenic molds contamination in foods also increased health risk to human and animals Negash [10]. Other researchers had reported that food is contaminated through various factors which include poor storage conditions, poor handling practices, poor hygiene of the food handlers and inadequate processing Feglo and Sakyi [11]. Other researchers had associated the presence of mycotoxigenic molds in foodstuff with the presence of mycotoxins Campbell [12].

Promoting high quality and food safety standards in schools is necessary for the good nutrition, health and continued education of school children Osaili et al. [13] and Oranusi et al. [14]. Children had been reported to be more at risk to dietary mycotoxins exposure than older people Azziz-Baumgartne [15], Center for Disease Control (CDC) [16], Okoth and Ohingo [17] due to their low developed immune system, increased food demand and uncontrolled diet Gong et al. [18]. High exposure to mycotoxins had been reported to children that largely consume maize based foods in countries such as Tanzania Kamala et al. [19] Kenya Herrera [20] and Nigeria Ojuri et al. [21]. In Kenya, it had been previously reported that 150 school going children died and about 500 were hospitalized due to exposure to mycotoxins contaminated diets Angel [22]. Mycotoxins illnesses outbreak were also reported in United State of America where 155 school children at elementary school were ill from intake of mycotoxins contaminated school meal WHO [23]. Despite increased usage of maize based meals in School Meals Program, there is limited information on postharvest handling knowledge of maize foods and practices among food handlers in Salima District in Malawi. Therefore, this study was developed to determine postharvest handling knowledge and practices of food handlers regarding mycotoxigenic molds contamination in maize based diet under home-grown school meals program in Salima district, Central region of Malawi.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study was implemented between August and November, 2019 in Salima district, Central Malawi. Salima is one of the districts in Malawi implementing School Meals Program through home-grown school meals program. The program covers three Extension Planning Areas (EPAs) namely: Katelera, Chipoka, and Tembwe. The Extension Planning Areas are demarcated based on agro-ecological zones.

Salima district covers 2,196 km square area with the population of about 478,346 of which 53% are under 18 years National Statistical Office (NSO) [21]. It is located along the lake shores of Malawi in central region (Fig. 1). The district has a sub-tropical climate, which is relatively dry and strongly seasonal. The wet season is hot, and the dry season is warm, windy, and mostly clear.

2.2 Study Design

This was cross-sectional study with qualitative and quantitative component. Data was collected using a structured questionnaire in primary schools implementing home grown school meals program in Salima District in central Malawi.

2.3 Sample Size Determination

A total of 31 schools and 124 food handlers was involved in the survey. The sample size of schools was calculated using formula of Yamane (1967); $n= N/1+N(e)^2$, where n = the required sample size, N = the total number of schools Program (44), and e = level of precision. The level of precision of 0.10 was used to obtain appropriate sample representing the population of schools under the study.

This resulted into $\mathrm{n} = \frac{44}{1+44\,(0.10)^2}$ =31 schools.

The number of food handlers was calculated using formula of Fisher et al. (1998); $N=Z^2pq/d^2$, where N = the required sample size, Z = the normal standard variation at 95% Confident Interval (1.96), p = the expected proportion of the population of food handlers under Home-grown school meals program (0.5), q = the expected ratio of food handlers not under the program of study (1-p), and d= level of precision. The level of precision of 0.09 was used to obtain appropriate sample representing the population of food handlers under the study.

This resulted into $\mathrm{n} = \frac{1.96^2 \text{x } 0.05 \text{ x } 0.5}{0.09^2} =$ 124 food handlers.

Different levels of precisions were used to obtain the highest possible number of the food handlers as they are not many in a schools.

2.4 Sampling Procedure

The simple random sampling technique was used to select 31 Primary Schools among those implementing Home-grown school meals program. One hundred twenty-four (124) food handlers were purposively selected from the sampled schools and interviewed using the structured questionnaires. These food handlers were School Meals Cooks, Food Suppliers, Food committee members and the School Stores Keepers.

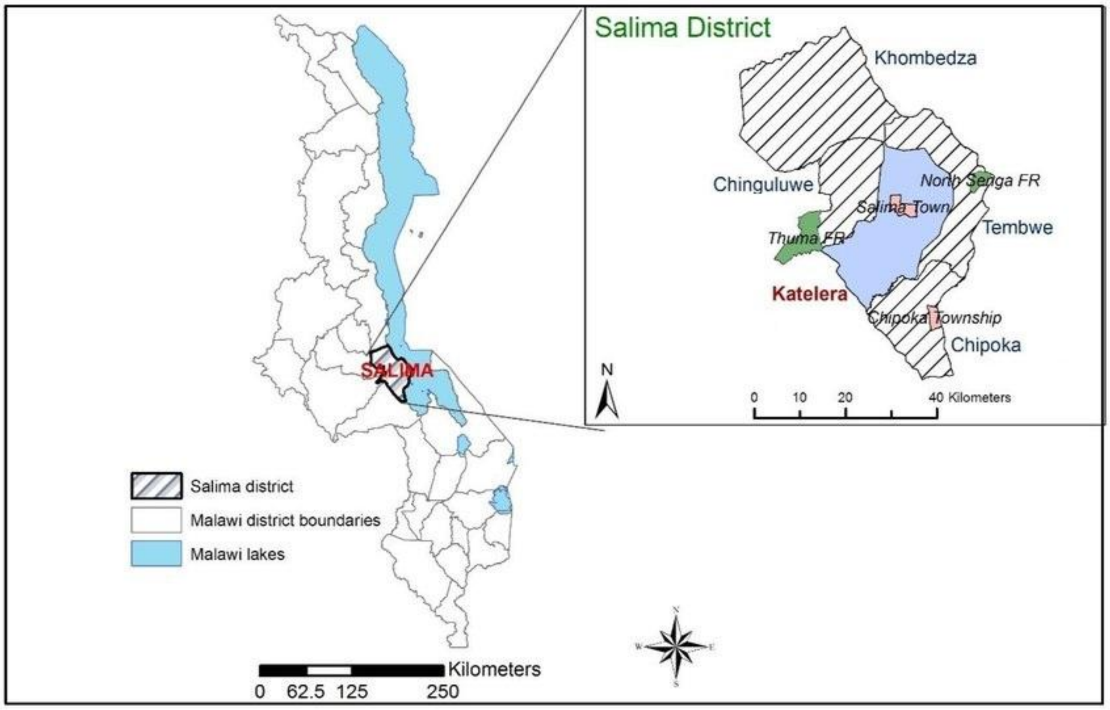

Fig. 1. Location of Salima district in Malawi. Source: (Musa et al. 2018)

2.5 Data Collection

The data was collected through administering the structured questionnaires to individual food handlers. The questionnaire was designed to capture demographic characteristics of the respondents, knowledge and practices concerning causes of mycotoxigenic molds during maize storage, associated health effects of mycotoxigenic molds, knowledge of aflatoxins and fumonisins contaminations in maize foods, control measures of mycotoxigenic molds, attendance to postharvest handling training, sources of foodstuff in schools, handling practices during transportation, reception, storage and processing in schools.

Knowledge of the respondents was assessed using the "True", "False" and "Don't Know" statements, while the practice was assessed through the "Yes" and "No" questions and observations. The overall knowledge assessment adopted Blooms cut-off points grade scores of ≤ 59% as low knowledge, 60 to 79% as moderate knowledge and 80 to 100 as high knowledge Nahida. [24], Abdullahi et al. [25]. These scores were allocated to the scale range of 1-23 points (representing a total number of 23 knowledge statements) which was categorized into three levels of 1-14, 15-19, and 20+, respectively.

2.6 Statistical Data Analysis

The data was subjected to Statistical Package for Social Scientists (Version 20.0) for Windows®. Data was analyzed through descriptive statistics in order to obtain frequencies, percentages, mean and standard deviations. The One-way analysis of variance (ANOVA) was applied to compare the mean scores among the demographic characteristics of the respondents. The independent t-test was also used to compare the significant differences between the mean scores of demographic characteristics of respondents and knowledge of mycotoxigenic molds. The associations of knowledge, practices and demographic characteristics of the food handlers were analyzed through Pearson Correlations.

3. RESULTS

3.1 Demographic Characteristics of the Respondents

The results on demographic characteristics of the respondents showed that 39% were male and 61% were female. The age of respondents ranged from 24 to 74 years with mean value of 40 ± 10 years. Respondent's level of education ranged from primary (62%) to tertiary (9%), while 6% had not attended formal education (Table 1). The results showed that majority of respondents (61%) had attended primary level. However, there was no correlation of age of the respondents and level of education (r = -0.127, P = 0.16). The significant association was observed between gender and level of education where men had significantly attended higher level of education than women (X^2 = 11.694, P= 0.001). Furthermore, the results showed no significant association of gender and age of the respondents (X^2 = 41.001, P = 0.16).

3.2 Postharvest Handling Knowledge of Food Handlers on Occurrence of Mycotoxigenic Molds Contamination in Maize Foods

3.2.1 Knowledge of the respondents on causes of mycotoxigenic molds during storage

Eighty-three percent (83%) of the respondents had knowledge that placing maize on bare ground or in contact with floor and wall cause mycotoxigenic molds, 82% indicated that wet or leakage store room can cause mycotoxigenic molds, 75% had mentioned that mycotoxigenic molds occur when stored maize grains are not fully dried. Seventy percent (70%) had knowledge that mycotoxigenic molds occur due to insects and pest attack, while 60% had mentioned that over-storage of maize grains and rodents cause molds contamination (Fig. 2). Overall, large proportion of respondents (80%) had high knowledge about causes of the mycotoxigenic molds in maize foods. Furthermore, there were no significant differences in knowledge of the causes of mycotoxigenic molds across respondents age and gender (P = 0.15). A significant difference was observed within level of education (P = 0.03) where those who attended higher level of education had high knowledge of the causes of mycotoxigenic molds that those of lower education level.

3.2.2 Knowledge of the respondents on the side effects of food consumption contaminated with mycotoxigenic molds

Seventy-eight percent (78%) of the respondents had knowledge that mycotoxigenic molds affect human health in general, while 70% had knowledge that mycotoxigenic molds cause infections such as nausea, vomiting and diarrhea. Thirty-two percent (32%) had knowledge that consuming moldy contaminated maize foods can impair child growth and/or cause malnutrition, 31% had mentioned that mycotoxigenic molds can cause death, while 27% had reported that intake of molds contaminated food can cause cancer (Fig. 3). Overall results showed that 47% of the respondents had moderate knowledge of the side effects of mycotoxigenic molds to human health in general, while 30% had high knowledge of the specific chronic health effects associated with consumption of mycotoxigenic molds. In addition, the results showed no significant differences in knowledge of the side effects of food consumption with mycotoxigenic molds among demographic regions of respondents (P>0.05).

Table 1. Demographic characteristics of the respondents

Characteristics	Quantity or size (n=124)	Relative frequency or percentage (%)
Gender		
Male	48	39
Female	76	61
Age		
20-29	18	15
30-39	43	35
40-49	44	36
50-59	14	11
60-69	2	2
70+	3	2
Education level		
Primary level	77	62
Secondary level	29	23
Tertiary level	11	9
None	7	6

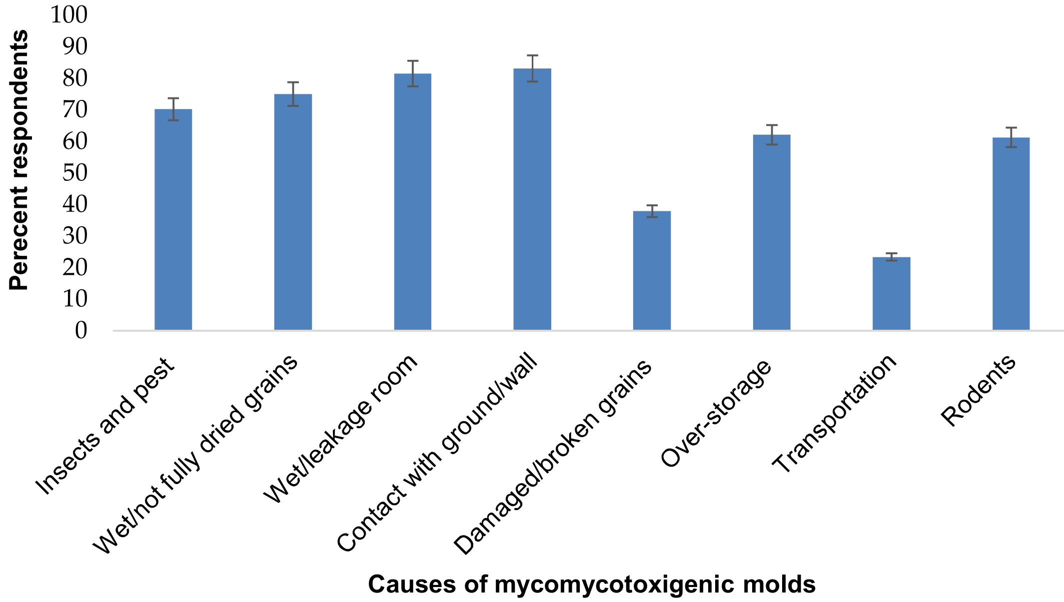

Fig. 2. Knowledge of the causes of mycotoxigenic molds occurrence during storage. Error Bars show standard errors of the mean

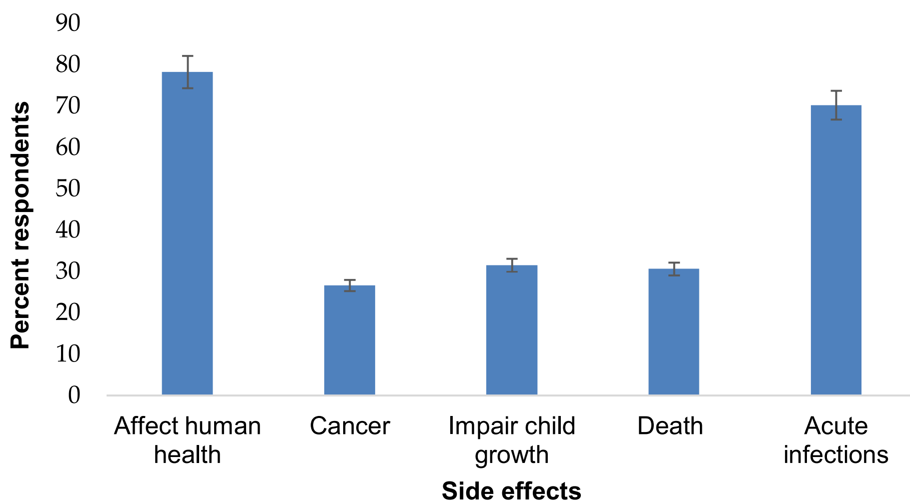

Fig. 3. Knowledge of the side effects of consuming mycotoxigenic molds. Error Bars show standard errors of the mean

3.2.3 Knowledge of the respondents about the occurrence of toxins with molds

Seventy-nine percent (79%) of respondents had knowledge that molds contain toxic substances in general. When respondents were asked about the knowledge of mycotoxins "aflatoxins" and "fumonins", only 15% and 4% were familiar or aware of the terms "aflatoxins" and "fumonisins", respectively. Overall, 85% of the respondents were not aware of mycotoxins in molds. There was significant different in knowledge of mycotoxins within respondents' level of education, where those that attended tertiary level had higher mean scores of knowledge of mycotoxins than the primary level ($P < 0.05$).

Furthermore, there were no significant differences in knowledge of mycotoxins across respondents age and gender (p >0.05).

3.2.4 Knowledge of the respondents about control measures of mycotoxigenic molds

Eighty-six percent (86%) of the respondents had knowledge that sorting and grading of damaged or rotten maize grains control mycotoxigenic molds, while 85% had reported that treatment of maize grains with pesticides and insecticides prevents molds contamination. Fifty-one percent (51%) had knowledge that mycotoxigenic molds can be controlled by the traditional methods of processing maize flour which include dehulling, soaking and drying, while 42% had indicated that toxins in molds can be reduced by cooking methods such as roasting, boiling and steaming (Table 2). Overall results showed that 50% of the respondents had moderate knowledge of the control measures of mycotoxigenic molds in maize foods. There were no significant differences in knowledge about control measures of mycotoxigenic molds among demographic regions of respondents (P > 0.05).

3.2.5 Attendance of respondents to training on postharvest handling of maize foods

Thirty-two percent (32%) of the respondents had reported that they attended training on postharvest handling of maize foods, while 68% did not attend. When respondents were asked to specify topics covered during trainings, they reported about control of maize weevils and Large Grain Borers (LGB), and stores managements for food commodities in schools. Despite that majority (68%) had not attended training on postharvest handling of maize foods, there was no significant different in knowledge or understanding of aflatoxins and fumonisins between respondents that attended training and those that did not attend training (P = 0.61).

Overall results showed no significant association of knowledge of mycotoxigenic molds with gender of the respondents (X^2 = 20.328, P = 0.857). Furthermore, there was no correlation of knowledge of mycotoxigenic molds with age of the respondents (r = 0.145, P = 0.105). The correlation though weak was observed between knowledge of mycotoxigenic molds and respondents level of education (r = 0.310, P = 0.000), where those who attended higher level of education had significantly higher knowledge of mycotoxigenic molds than those who had attended low education level (P < 0.05).

3.3 Food Handlers Practice in Relation to Mycotoxigenic Molds Contamination in maize Based Foods in Schools

3.3.1 Source of maize foods in schools

Nighty-eight percent (98%) of the respondents had reported that maize foods were sourced from Farmer Based Organizations such as cooperatives and associations, 24% had indicated that maize foods in schools are supplied by government, while 17% had reported that vendors supply maize foods to schools (Fig. 4). When respondents were further asked about the selection criteria of the suppliers, 93% reported that suppliers were selected through competitive bidding or open tender to supply the commodity (Fig. 5), for a period of 1 academic term (normally 3 months). The results clearly showed that maize foods were sourced from Farmer Based Organizations.

3.3.2 Handling of maize foods during transporting to schools

Large proportion of the respondents (59%) reported that maize foods were transported to schools uncovered on open Pickup trucks or Lorry, while 54% had indicated that maize foods was transported to school well covered on open Pickup trucks or Lorry. Fourteen percent (14%) had reported that maize foods was transported uncovered on Ox-Cart and 7% had reported that maize foods was transported uncovered on bicycles (Fig. 6). Overall results showed that large proportion of the respondents (82%) transported or delivered maize foods to schools uncovered or unprotected from the soil dust.

3.3.3 Handling of maize foods during reception in schools

Sixty-six percent (66%) of the respondents had reported that maize bags were offloaded direct on bare ground, 62% had indicated that maize bags were stored without winnowing or grading. A relatively small proportion (37%) of respondents had reported that maize bags were offloaded on mat/tents, 18% had reported that maize foods were winnowed before storage and 16% had indicated maize were graded/sorted before storage (Table 3). These results showed that maize bags were exposed to soil contacts as reported by majority of respondents that maize bags were offloaded direct on bare ground and stored without winnowing in order to remove some soils dust and other foreign matters. Furthermore, the results showed no significant differences in handling of maize foods during reception among demographic regions of respondents (P >0.05).

Table 2. Respondents knowledge on control measures

Factor	Quantity or size (n=124)	Relative frequency or percentage (%)
Sorting/grading damaged/rotten maize/foreign objects	107	86
Pesticides and insecticides application	105	85
Avoid storing maize with other non-food items	60	48
Feed livestock the contaminated maize grains	37	30
Process maize flour through traditional methods	64	52
Cook maize foods	52	42

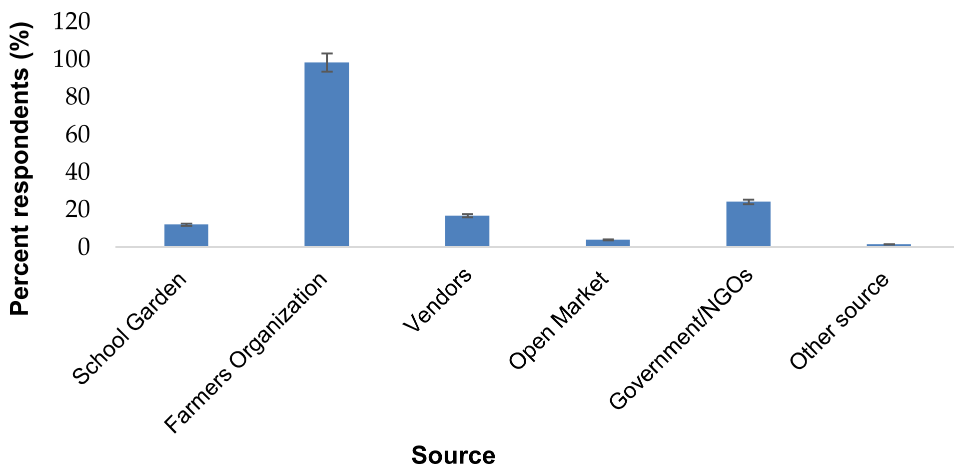

Fig. 4. Source of maize foods in schools

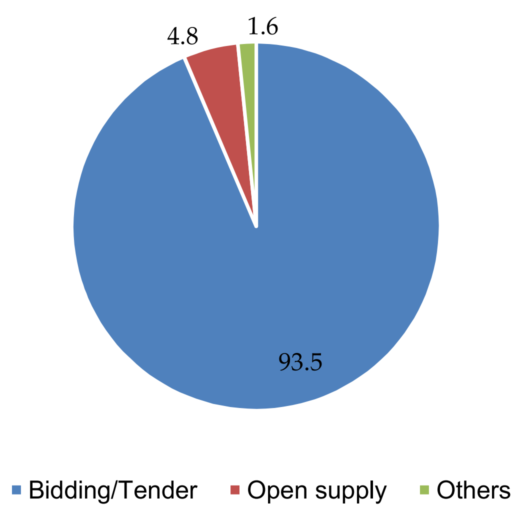

Fig. 5. Selection criteria of maize suppliers in schools

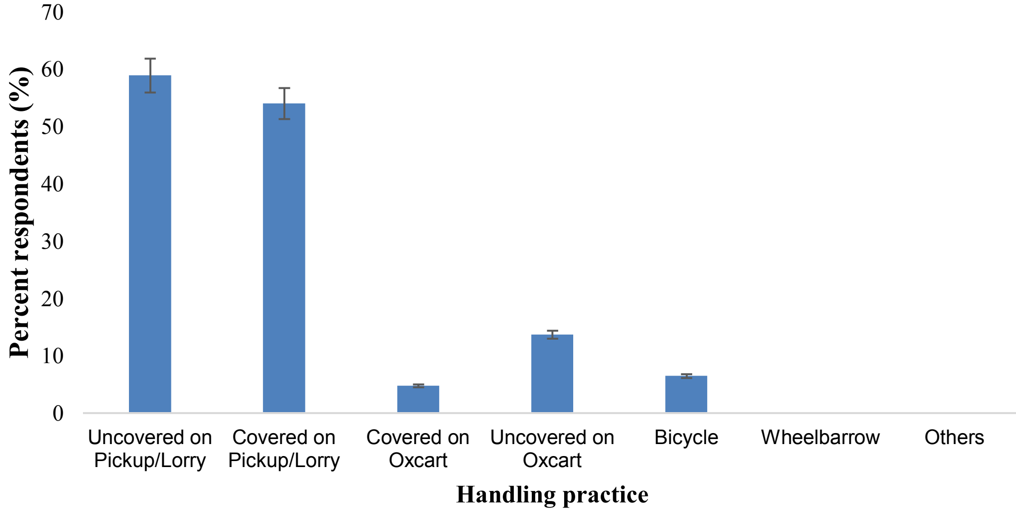

Fig. 6. Handling of maize foods during transporting to schools. Error Bars show standard errors of the mean

Table 3. Handling of maize foods during reception in schools

Factor	Quantity or size (n=124)	Relative frequency or percentage (%)
Offload direct on bare ground	82	66
Offload on mat/tent	46	37
Grade or sort before storage	20	16
Winnow before storage	22	18
Store without winnowing/grading	77	62
Others	4	3

Table 4. Storage of maize foods in schools

Factor	Quantity or size (n=124)	Relative frequency or percentage (%)
Cool and dry place	96	77
Clean place	98	79
Bags packed in contact with floor/wall	13	11
Bags packed on a raised racks	101	82
Well ventilated room	75	61
Foodstuff stored separate room from non-food items	102	82
Foodstuff stored in room with other non-food items	33	27
Foodstuff in a classroom with leaners	5	4
Pest and rodents control	0	0

3.3.4 Storage of maize foods in schools

Eighty-two percent (82%) of respondents had reported that maize foods were stored in separate rooms away from other non-food items, 81% indicated that maize foods were stored on raised racks and 77% had reported that stored maize on cool and dry place. Twenty-two percent (26.6%) had reported that maize foods were stored in classrooms in which learning sessions took place due to lack of storage structures in schools (Table 4). However, when store -rooms were visited, it was observed that 60% of the storerooms had maize bags packed in contact with floor and wall, and some maize bags were stored in rooms together with other non-food items such as cooking utensils, school books, cleaning materials and construction tools which contradicted with verbal reports by respondents. Furthermore, some store-rooms were observed very dirty with soil dust, bats droppings and spider-nets. Overall results showed that 60% of schools had poor storage of maize foods which exposed maize grains to hazard foreign matters such as soil, bird's droppings, chalk dust and other chemicals from the construction materials. There were no significant differences in storage practices of maize foods among respondents across demographic regions (P >0.05).

3.3.5 Attributes used in determining good quality maize foods in schools

Ninety-three percent (93%) of the respondents had reported that they determined maize quality through observation (visual) of grains free from decay or rotting, 54% had reported that they observed colour change, while 35% had indicated that they observed undamaged grains. None of the respondents had reported of laboratory based test (Fig. 7). The results shown that large proportion of the respondents determined quality of maize by observing physical appearance of grains. There were no significant differences in the attributes used in determining good quality of maize foods across demographic regions of respondents (P >0.05).

3.3.6 Processing of maize foods in schools

Eighty percent (80%) of respondents had reported that they winnowed maize grain before milling into flour, 57% had indicated that they sorted moldy or rotten maize grains before milling into flour, while 77% had reported that they milled maize grains without washing. Thirty percent (30%) of the respondents had indicated that do not remove moldy maize grains despite seeing them due to limited time of processing and preparation of the school meal (Table 5). These results raised doubt that majority of respondent's thoroughly sort, winnow and wash maize grains for school meals. However, the results showed no significant differences in practices during processing of maize foods in schools across demographic regions of the respondents (P >0.05).

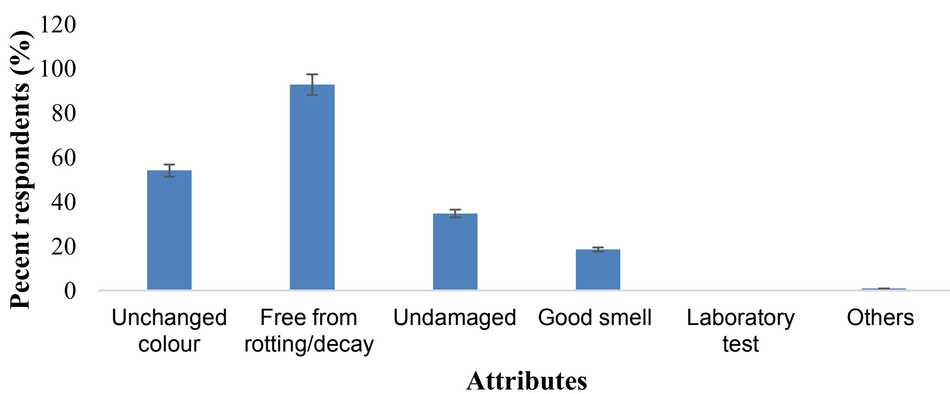

Fig. 7. Attributes of determining good quality maize in schools. Error Bars show standard errors of the mean

Table 5. Processing of maize foods in schools

Factor	Quantity or size (n=124)	Relative frequency or percentage (%)
Grading/ sorting	70	57
Winnow before milling	99	80
Wash maize grains before milling	26	21
Dehull maize grains and mill	21	17
Wash grain and mill	11	9
Mill maize grain without washing	95	77
Do not remove moldy grains when processing	37	30
Others	14	11

Overall the results showed no significant association of postharvest handling practice of maize foods with gender of the respondents ($X^2 = 8.381$, P = 0.397). Furthermore, there was no correlation of postharvest handling practices of maize foods with age (r = 0.084, P = 0.334), and education level (r = 0.083, P = 0.360) of the respondents.

4. DISCUSSION

4.1 Demographic Characteristics of the Respondents

The demographic characteristics of the respondents revealed that the study had more women participants than men. Generally and traditionally, most food processing activities are carried out by women than men in Malawi WFP [26]. The World Food Programme in Malawi also support empowering of women volunteer Cooks in School Meals Program. Several food and nutrition related programs have shown to have more women participation than men WFP [26]. The study by Webb et al. [27] reported no significant differences in handling of foods between men and women, of which all had unsatisfied scores of food safety. The results of the present study compare well with previous studies that reported high proportion of women in most food related programs than men Akabanda et al. [28], Son et al. [29]. However, the results of the current study contradicts with those of Pius [30] who had reported more community men participation in school meals program than women. Majority of the respondents in the current study were above 35 years of age. A person of over 35 years of age is considered an adult in Malawi, which would translate mature to handle and care children than younger aged ones. According to Webb [27], older people handle food better than younger ones. High education level is associated with better food handling hygiene and food safety Ababio et al. [31], of which in the present study majority of respondents particularly women had attended low education level, posing a threat to food safety in school meals program. This result agree with the previous study in Malawi which had reported that men had significantly higher level of education than women Matumba et al. [32].

4.2 Knowledge of the Respondents on Causes of Mycotoxigenic Molds during Storage

This study established that majority of food handlers had high knowledge of the causes of mycotoxigenic molds. This could be attributed to the regular farmers trainings on postharvest handling of food crops which the Ministry of Agriculture promotes in order to reduce postharvest losses in Malawi [33]. Further, the current study revealed no significant difference in knowledge of causes of mycotoxigenic molds across respondents' demographic regions. This study presumed respondents had equal access to information about mycotoxigenic molds. However, the current results contradicts with those of Magembe et al. [34], who had reported that women respondents were more knowledgeable of molds contamination in foods than men, and that respondents with higher level of education were more aware of molds in foods compared to the less educated ones. The results of the present study agree with several previous researchers who reported that large rural population in developing countries have knowledge of the mycotoxigenic molds in maize foods Udomkun et al. [35], Matumba et al. [32]. Storage of not fully dried commodities, poor temperature control, moisture content, soil contacts and inadequate ventilations, allows insects infestation and exacerbate fungal proliferations and mycotoxin production in foodstuffs (Matumba et al. [32] Misihairabgwi et al. 2017).

4.3 Knowledge of the Respondents on the Side Effects of Consuming Mycotoxigenic Molds

This study revealed low knowledge among food handlers on health effects associated with mycotoxigenic molds. This could be due to inadequate information on health issues related to mycotoxigenic molds. There are inadequate formal trainings in Malawi of food handlers on food safety (Morse et al. 2018), and no serious case of mycotoxins outbreak have been recorded Mwalwayo and Thole [36]. This might attributed to limited knowledge of food handlers on the effects of mycotoxins exposure. The results from the current study contracts with previuos studies which reported that men were more knowledgeable of health effect of molds than women counter part Matumba et al. [32]. The results of the present study are consistent with several reseachers who reported that most rural population in Southern Africa are less knowledgeable of health implications associated with consuming moldy contaminated maize foods Matumba et al. [32], Mboya and Kolanisi [37], Mukanga et al. [38]. Consumption of mycotoxins contaminated foods pose serious acute and chronic effects to the consumer's health Reddy et al. [39], which include carcinogenic, mutagenic, teratogenic, hepatotoxic and immunosuppression Mostrom [40], Liu and Wu [41], IARC [42].

4.4 Knowledge of the Respondents about Toxins Found in Molds

This study established that majority of food handlers had low knowledge of mycotoxins in mycotoxigenic moldy contaminated maize foods. The low knowledge of food handlers on mycotoxins might be associated with low level of education of food handlers. Adekoya et al. [43], had associated knowledge of mycotoxins with level of education. Udomkun et al. [35] had stressed that education is the powerful tool for sharing the information and knowledge. The results of the current study agree with several authors who reported that literate population had more knowledge of aflatoxins and other mycotoxins than those that did not attend formal education (Udomkun et al. [35]; Magembe et al. 2016 ; Matumba et al. [44]. This shows that education might have impact on the knowledge of mycotoxins among food handlers on school meals program. The results of the present study further agree with those of Suleiman et al. [45] that over 80% of the producers, sellers, and buyers were not aware of the mycotoxins in foods. Equally, several studies reported that majority of rural population in developing countries lack knowledge of mycotoxins Adekoya et al. [43], Matumba et al. [44], Udomkun et al. [35].

4.5 Knowledge of the Respondents about Control Measures of Mycotoxigenic Molds

As regards to control of mycotoxins, the study established that food handlers had moderate knowledge of the control measures of mycotoxigenic molds. Lack of capacity building on mycotoxins might contribute to inadequate knowledge of mycotoxins control among food handlers in school meals programme. It was evidenced in the present study that the postharvest handling trainings which was attended by food handlers did not include topics on mycotoxins. Study reports have shown that capacity building trainings for rural communities concerning mycotoxins contamination are hardly conducted in sub-Saharan Africa countries Mboya and Kolanisi [37], Mukanga et al. [37]. The present study however revealed no significant association of attending training on postharvest handling of maize foods with knowledge of mycotoxins. These results support findings by Matumba et al. [32], that large proportion of rural Malawians were not aware of effective control measures of mycotoxins in foodstuffs. Similar, other researchers reported that there is limited information in developing countries on control strategies of mycotoxins contamination in food commodities Phokane et al. [46], Torabi et al. [47]. From the findings of the present study, inadequate knowledge of food handlers on mycotoxins control may risk school children from consuming maize foods contaminated with toxins.

4.6 Source of Maize Foods in Schools

The present study revealed that foodstuffs in schools were sourced from farmer based organizations. The home-grown school meals program promote sourcing of foodstuffs locally for rural smallholder farmers economic empowerment WFP and FAO [48]. However, reports have shown that many subsistence farmers in Malawi live in poor houses that leak during rainy season and with poor aeration MNSO, [49], which can influence molds production in stored commodities Matumba et al. [32], before delivery to schools.

4.7 Handling of Maize Foods during Transportation, Reception and Storage

The present study revealed that food handlers practiced poor postharvest handling practice of maize foods which include transporting uncovered maize foods and placing bags in contact with bare ground or soil (Appendix 1). Poor handling of maize foods such as pacing maize on bare ground was reported in similar study as common practice in Malawi Matumba et al. [44]. The results of the current study contradicts with those of Midega et al. [50] who had associated postharvest handling practice with education levels, whereby farmers with higher level of education were reported practice proper postharvest handling of food commodities than illiterate farmers. The results from the present study are comparable with those of Mboya et al. [51] that most postharvest handling practices in rural communities are not adequate to protect maize foods from mycotoxins contamination. According to Demissie et al. [52], majority of farmers store maize in same house with people due to lack of proper storage structures. This was equally observed in the present study that foodsuffs were stored in classrooms with children learning to the other side of the same room. Poor postharvest handling of commodities have been reported to influence molds and mycotoxins production Milani [53]. Molds species such as *Aspergillus flavus, Aspergillus parasiticus* affect food crops at any stage in food chain including during transportation (Eshiett et al. [9]. Poor postharvest handling practices of maize foods among food might influence mycotoxigenic molds in maize based diets for school children.

4.8 Determination of Quality and Processing of Maize Foods in Schools

This study established that food handlers in school meals program determine maize quality through physical observation of the grains. Some food contaminates such as mycotoxins are toxic compounds in nature WHO [3] which cannot be physically observed. Laboratory test could be an ideal for determining the quality of foodstuffs. The results of the present study are consistent with those of Suleiman et al. [45], that many consumers determine quality of commodities through observing physical change of the grains such as broken grains, damage by insects and colour change. Other studies have associated the presence of mycotoxigenic molds in foodstuff with the presence of mycotoxins Campbell [12], which 30% of the respondents in the current study reported that do not remove moldy maize grains because of inadequate time for processing and preparation of school meals. These findings clearly reveal that maize foods in schools is not fully assessed for human consumption safety.

In general, the present study support previous studies that large population in developing countries have limited knowledge on mycotoxins issues like health impacts and control measures Changwa [54]. Lack of proper strategies to inform the general public on effects of mycotoxins and postharvest handling practices of foodstuffs remains an issue to food safety [47]. As evidenced in the present study, majority of food handlers in school meals program had high knowledge of mycotoxigenic molds despite practicing poor postharvest handling of maize foods. Food handlers had further demonstrated low knowledge of the associated health effects of mycotoxins. From the results of the present study, it is likely that the low knowledge and the poor postharvest handling practice of maize foods among food handlers in school meal program might predispose school children to mycotoxins contaminated maize based diets.

5. CONCLUSION

It can be concluded that food handlers under School Meals Program in Salima Distrct, Central Malawi have high knowledge of mycotoxigenic molds contamination in maize based foods. However, the study revealed that food handlers have low knowledge of the chronic health effects associated with consumption of food contaminated with mycotoxigenic molds and control measures. Furthermore, it has been established that food handlers have low knowledge of mycotoxins contamination in maize based diets. The poor postharvest handling practice of maize foods among the food handlers identified in this study may predispose school children to mycotoxins exposure. It is recommended that all stakeholders involved in School Meals Program should be extensively trained on mycotoxins and postharvest handling of maize foods to prevent school children from the risk of mycotoxins exposure.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 1

Photos showing poor postharvest handling practices of maize foods in schools under School Meals Program

Maize foods in contact with soil or ground during reception

Maize foods in contact with floor or wall during storage

Maize foods stored in room mixed with other non-food items

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