Knowledge, Attitude, and Management Practices of Stakeholders towards Fungal Invasion and Mycotoxin Contamination of Wheat and Maize in Ethiopia

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Abstract

Background: Filamentous fungi cause deterioration in grain quality and release harmful mycotoxins. Cereals are vulnerable to fungal invasion and mycotoxin contamination starting from the field to post-harvest storage and processing. However, information is limited on the fungal invasion of cereals and mycotoxin contamination in Ethiopia.

Objective: The study was aimed at determining the knowledge, attitude, and management practices of respondents towards fungi and their mycotoxin contaminations.

Materials and Methods: A total of 438 participants were sampled from four top wheat and maize producing Zones (Bale, West Arsi, East Shoa, and West Shoa) from Oromia Regional State, Ethiopia. Descriptive analysis, mean ranking, and test of significances were used to analyze the data.

Results: Based on the results obtained, the overall mean score level of knowledge of respondents towards fungal invasion and mycotoxin contamination was very low (1.81). The highest mean score level of knowledge towards fungal invasion and mycotoxin contamination was 2.54 for respondents working as agricultural experts and the minimum score (1.31) was obtained for respondents with elementary educational background. A significant difference in mean knowledge level ($P < 0.01$) was observed on the questions related to fungi and their mycotoxins among farmers, agricultural experts, merchants, teachers and other participants. The overall mean attitude level of respondents was 4.16. The highest mean attitude level (4.49) was obtained for teachers and the lowest mean attitude level (3.94) was obtained for respondents with elementary education background. The overall mean practice level of respondents towards reducing fungal infection and mycotoxin contamination was low (1.9). A comparison of mean practice levels base on occupation type showed significant ($P < 0.01$) differences among the various occupation types.

Conclusion: The study revealed knowledge about fungi and mycotoxin contamination is generally very low among farmers. This signals the need for providing training for farmers at all levels on toxin producing fungi and the danger of their mycotoxins present to humans and animals.

Keywords: Attitude; Cereals; Knowledge; Occupation type; Respondents

1. Introduction

Wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) are important sources of carbohydrate and constitute the dominant portion of staple cereals in Ethiopia both in urban and rural areas (Sheehy *et al*., 2019). These cereals are vulnerable to fungal invasion and mycotoxin contamination starting from the field to post-harvest storage and processing until being served on a table (Ünüsan, 2019; Leite *et al*., 2020). The majority of the farmers in the country are way back from good agricultural practices, and the crops produced are highly subjected to fungal invasion and mycotoxin contamination (Haftom Kebede *et al*., 2020). Beside the poor agricultural practice, the fungi take advantage of the warm climatic condition of the country to invade the grains and release their toxic secondary metabolites into the grains (Temba *et al*., 2021). These aforementioned conditions are aggravated by the lack of awareness about the conditions favoring fungal growth and proliferation.

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ISSN 1993-8195 (Online), ISSN 1992-0407(Print)

Fungal invasion on wheat and maize reduces the visual quality of the grain and results in a deteriorated price of the grain. Fungal invasion before harvest could unstoppably lead to post-harvest grain deterioration, quality loss, price reduction, and consumer health hazards (Schmidt *et al*., 2016). This grain quality loss and health hazards are many-fold in developing countries like Ethiopia where manual harvesting and threshing of grains are widely practiced (Wondimeneh Taye *et al*., 2018).

Fungi are a highly diverse group of organisms capable of colonizing diverse substrates and impart their mycotoxins to the substrate (Leite *et al*., 2020). Mycotoxins are fungal secondary metabolites that are toxic to human and animal cells of which the dominant mycotoxins are produced by fungi belonging to the genera *Aspergillus*, *Fusarium*, *Penicillium*, and *Alternaria* (Geremew Teshome *et al*., 2016; Escriva *et. al*, 2017). The major mycotoxins based on their occurrence and impact on human and animal health comprises aflatoxins, ochratoxins, fumonisins, trichothecenes, deoxynevalinone, citrinine, and patuline (Schmidt *et al*., 2016). Among these mycotoxins aflatoxins are the most carcinogenic of all naturally occurring fungal secondary metabolites produced by *Aspergillus flavus* and *Aspergillus parasiticus* (Temesgen Asefa *et al*., 2020). Ochratoxins are mainly produced by a diverse group of filamentous fungi among the genus *Aspergillus* including *Aspergillus westerdijkiae*, *Aspergillus ochraceus*, and *Aspergillus steynii,* and by the genus *Penicillium* (*P. notatum*) (Geremew Teshome *et al*., 2016; Escriva *el al., 2*017). Ochratoxins exerts nephrotoxic, hepatotoxic, genotoxic, immunosuppressive, and carcinogenic effects on animal cells (IARC, 1993; Sorrenti *et al*., 2013). Fumonisins are produced by *Fusarium verticillioides* and *F. proliferatum,* and *Penicillium fumonisins* (Deepa *et al*., 2016) targeting kidneys and liver (Ünüsan, 2019). These mycotoxins have ever raised human and animal health concerns due to their wider occurrence in different agricultural products.

Fungal toxins can occur in different cereal grains like maize, sorghum, wheat, rice, barley, and oat and animal feeds (Ogunade *et al*., 2018). The toxin-producing fungi possibly get access to the cereals during pre-harvest, during harvest, or post-harvesting during storage and processing. Once toxin producing fungi get access to the grains or any other product destined for human consumption dietary exposure to mycotoxin will follow (Atongbiik *et al*., 2017). Food processing practices like grinding, juice extraction, fermenting, roasting, boiling, could not result in the complete removal of mycotoxins from the food commodities (Pallarés *et al*., 2019). Several reports showed the dietary exposure of human to different mycotoxins trigger acute or chronic toxicity (Pallarés *et al*., 2019; Vin *et al*., 2020). In developing countries where the poor agricultural practice coupled with food insecurity, the already disadvantageous communities consume low-quality cereals and become more vulnerable to mycotoxin dietary exposure.

Fungal invasion and preventive measures against their mycotoxins are based on the understanding of the prevailing environmental conditions for the proliferation and spread of the fungi and their spores. Ethiopian wheat and maize producing farmers have some indigenous knowledge on how to protect their crops from insect and pest infestation during pre- and post-harvest processing (Duressa Tarekegn 2018; Birhanu Hiruy and Emana Getu, 2018). However, it was hypothesized that the farmers might have no adequate knowledge of the nature of toxin producing fungi, mycotoxins and their health impacts, and the prevention mechanism to fungal invasion. It was speculated that lack of understanding of these fungi and mycotoxins leads to the consumption of wheat and maize invaded by the fungi. Thus, the main objective of this study was to investigate the knowledge, attitude, and practices of stakeholders towards fungi and mycotoxins in maize and wheat. Therefore, this study was conducted to determine the variable most affecting the practice of participants in reducing fungal invasion and mycotoxin contamination in wheat and maize production.

2. Material and Methods

2.1. Study Locations, Participants, and Design

A total of 438 participants were selected based on quota sampling from top maize and wheat-producing zones of Oromia regional state (Figures 1, 2 and 3). Seven top wheat and maize producing districts were selected based on their production potential and the respondents included were farmers, agricultural experts (AEs), merchants, teachers, and other consumers. The participants in the study districts were drawn from eight towns and 16 rural villages based on quota sampling techniques. Zonal administrations, districts, and villages were selected based on maize and wheat production potential. The study was designed to obtain a better composition of participants from all sampling districts.

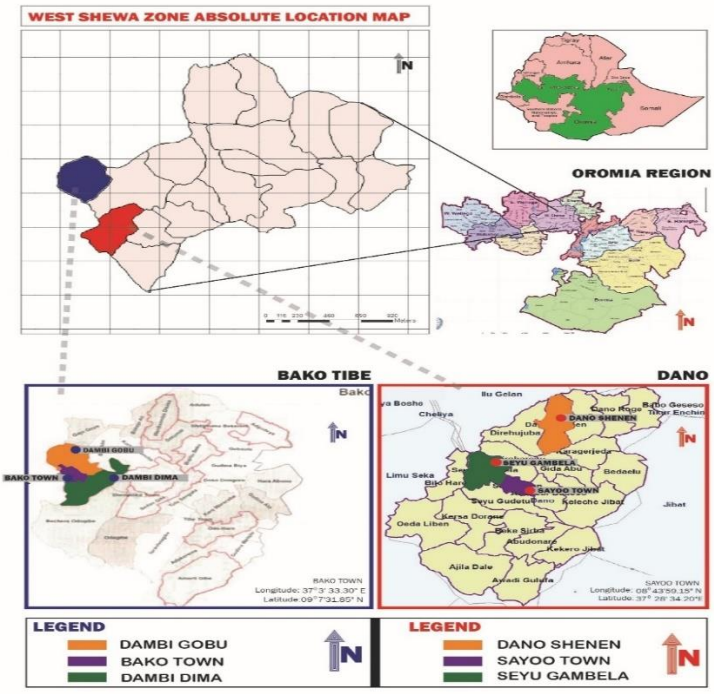

Figure 1. Absolute location map of West Shoa Zone, Oromia National Regional State of Ethiopia.

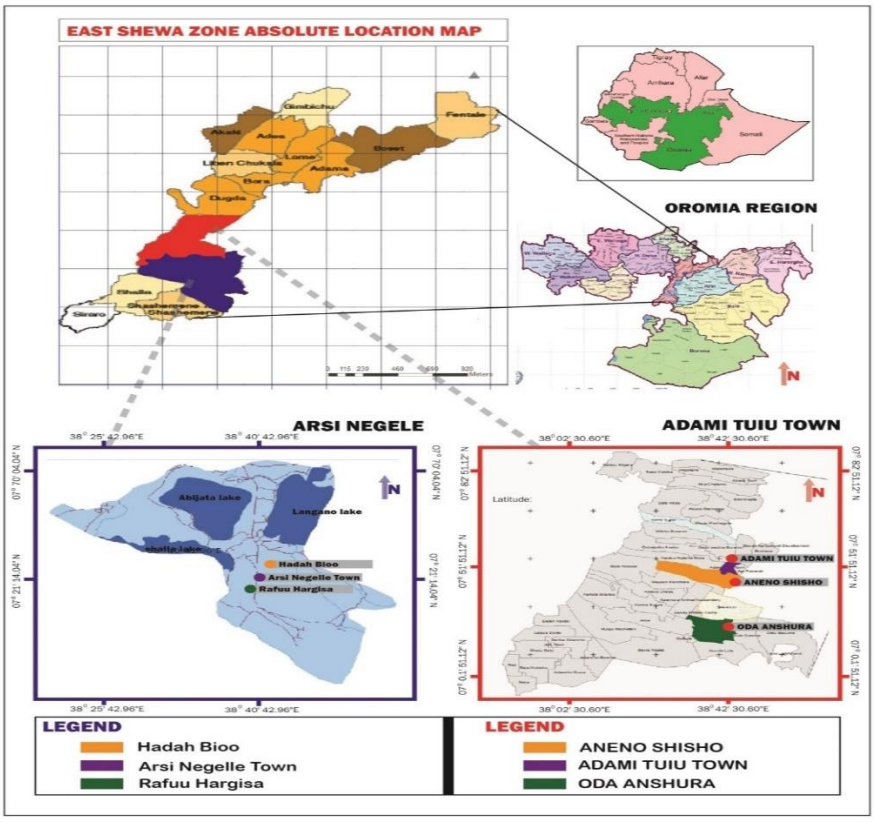

Figure 2. Absolute location map of East Shoa Zone, Oromia National Regional State of Ethiopia.

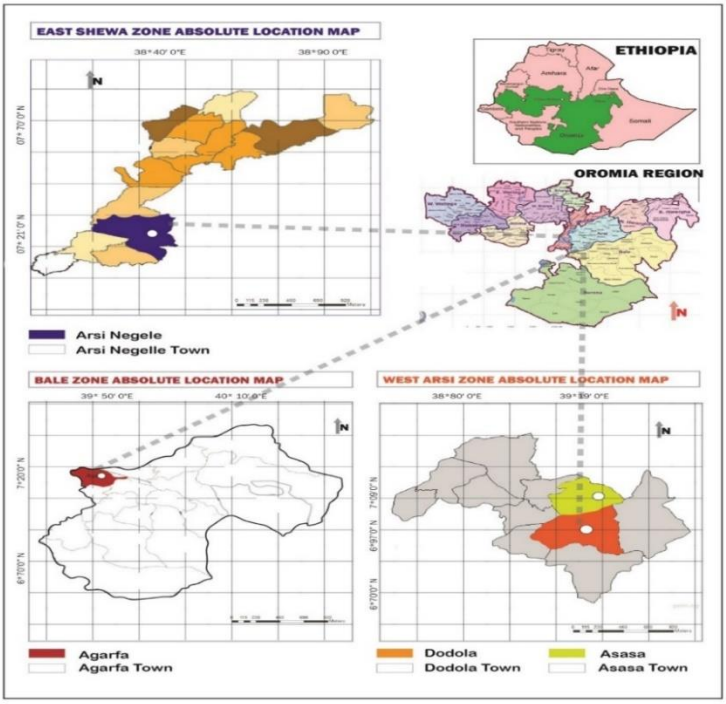

Figure 3. Absolute location map of East Show, Bale and West Arsi Zones of Oromia National Regional State of Ethiopia.

Sixteen interview administrators with a minimum academic qualification of diploma were recruited and trained for two days on how to perform a survey and administer interview questions. A simple manual was prepared for the interview administrator and pretested during the time of selecting respondents. The survey was conducted from 20 January to 4 February 2018. A team consisting of three individuals (two trained interview administrators and one agricultural extension worker as a village guide) with all the necessary facilities was deployed to every district. Sampling of the respondents was based on the quota method and once the quota was allocated, interview administrators began from the center of the village and proceeded towards the east side of the village by sampling every third household. In case, a household head was not available for the interview, the next household was sampled and the procedure continued eastwards until all the targeted households were interviewed. Once eastward households were all interviewed, the same procedure was followed starting from the center to the west, north, and south until the required respondents were obtained.

2.2. Administering Questionnaires

Three categories of questionnaires were prepared to capture knowledge, attitude, and practice of respondents. The first category contained knowledge-related questions, the second category contained attitude-related and the third category contained practice-related questions. A team containing two individuals per village administered the questionnaires. A principal investigator and a co-investigator were assigned to supervise the interview administration process. All the questionnaire administrators were trained and their competence in questionnaire administration skills was deemed satisfactory based on a pretesting exercise. Before administering the questioners, verbal consent was obtained using a standardized consent script. The questionnaires were administered in local languages (Afaan Oromo or Amharic). The completed questionnaires were manually checked for clarity and completeness and coded before being entered into Epi Info. The data were exported to Microsoft excel and analyzed using R Statistical software and SPSS V20.

2.3. Data Analysis

For statistical evaluation of the data R statistical software version 3.0.3, SPSS version 20, and Microsoft Excel were used. Pearson correlation analysis was performed to see the relationship between socio-demographic factors and mean knowledge level. Descriptive analysis was carried out to summarize the socio-demographic characteristics

of the respondents based on frequency distribution and percentages. Mean ranking analysis was used to understand the stakeholders' knowledge, attitude and management practice level towards fungal invasion and mycotoxin contamination. Kruskal Wallis test ($\alpha = 0.05$) was performed to examine significant differences between the mean knowledge, attitude, and practice levels of the respondents.

3. Results

3.1. Socio-demographic Characteristics of the Respondents

The results of the socio-demographic characteristics showed that 75% of the respondents were male and 25% were female (Table 1). One hundred and forty-one (32.2%) of the participants were aged between 31 to 40 years. One hundred and thirty-three (30.4%) of the respondents were in the age group of 21 to 30 years. The remaining 93 (21.2%) and 58 (13.2%) of the participants were aged between 41 and 50, and above 50 years, respectively. Some 13 (3%) of the participants were between the age of 18 and 20 years. Three hundred and seventy-five (85%) of the respondents were married and the remaining 47 (10.7%), nine (2.1%), and seven (1.6%) were single, widowed, and divorced, respectively.

3.2. Knowledge of Respondents towards Fungi Invasion and Mycotoxin Contamination on Wheat and Maize

The overall mean score level of knowledge of respondents towards fungal invasion and mycotoxin contamination was very low (1.81) (Table 2). The highest mean score level of knowledge towards fungal invasion and mycotoxin contamination was 2.54 for respondents working as agricultural experts and the minimum score (1.31) was obtained for respondents with the background of elementary education (Figure 4). No significant difference was observed in the level of knowledge between males and females ($P > 0.05$) (Table 3

Table 1. Socio-demographic profile of the respondents in the four administrative Zones of Oromia National Regional State during the 2018 cropping year.

Variable	Variable class	Frequency	Percent
Gender	Male	327	74.7
	Female	111	25.3
	Total	438	100
Age	<20	13	3
	21-30	133	30.4
	31-40	141	32.2
	41-50	93	21.2
	51 and above	58	13.2
	Total	438	100
Marital status	Divorced	7	1.6
	Married	375	85.6
	Single	47	10.7
	Widowed	9	2.1
	Total	438	100
Educational status	No education	98	22.4
	Grade 1-4	64	14.6
	Grade 5-8	118	26.9
	Grade 9-12	73	16.7
	Diploma and above	85	19.4
	Total	438	100
Occupation	1. Farmers	236	53.9
	2. Merchant	53	12.1
	3. Agricultural Expert	19	4.3
	4. Teacher	18	4.1
	5. Other	112	25.6
	Total	438	100

Table 2. Mean knowledge level of respondents in four administrative zones of Oromia National Regional State during the 2018 cropping year.

Statements capturing knowledge of respondents	Responses						Mean	Standard deviation
	1(no)		2(not sure)		3(yes)			
	Number	%	Number	%	Number	%		
Have you ever heard about the name fungi/mold	108	24.7	49	11.2	281	64.2	2.39	0.86
Have you heard of the word mycotoxin	362	82.6	23	5.3	53	12.1	1.29	0.67
Have you heard of the word Afflation	270	61.6	25	5.7	43	9.8	1.25	0.62
Have you heard of the word Ochratoxin	422	96.3	0	0.0	16	3.7	1.08	0.38
Have you heard of the word Fumonisin	394	90.0	26	5.9	18	4.1	1.14	0.45
Have you heard about mycotoxins occurrence in maize	298	68.0	5	1.1	135	30.8	1.63	0.92
Have you heard about mycotoxins occurrence in wheat	288	65.8	37	8.4	113	25.8	1.60	0.87
Do you know that mycotoxins can cause disease	129	29.5	67	15.3	242	55.3	2.26	0.88
Do you know that mycotoxins can cause stunting	184	42.0	144	32.9	110	25.1	1.83	0.80
Do you know that mycotoxins can cause cancer	203	46.3	157	35.8	78	17.8	1.71	0.75
Do you know that mycotoxins can suppress immunity	160	36.5	149	34.0	129	29.5	1.93	0.81
Do you know that mycotoxins can harm livestock	224	51.1	91	20.8	123	28.1	1.77	0.86
Do you know that mycotoxins survive cooking temperature	198	45.2	127	29.0	113	25.8	1.81	0.82
Do you know that mycotoxins accumulate in animal products	205	46.8	127	29.0	106	24.2	1.77	0.81
Do you know that the ware houses hold be checked frequently	141	32.2	21	4.8	276	63.0	2.31	0.93
Do you know that wheat and maize should be free from mites and insects	154	35.2	8	1.8	276	63.0	2.28	0.95
Do you know that mycotoxin can cause stomachache	146	33.3	48	11.0	244	55.7	2.22	0.93
Do you know that mycotoxins can cause headache	205	46.8	104	23.7	129	29.5	1.83	0.86
Do you know that mycotoxins can cause fever	204	46.6	121	27.6	113	25.8	1.79	0.83
Do you know that mycotoxins can cause vomiting	174	39.7	105	24.0	159	36.3	1.97	0.87
Do you know that molds are harmful to human and animals	141	32.2	56	12.8	242	55.3	2.23	0.91
Mean and Standard Deviation							1.81	0.15

Table 3. Knowledge of respondents by gender and occupation types in four administrative zones of Oromia National Regional State during the 2018 cropping year.

Statements capturing knowledge of respondents	Gender		Occupation				
	Male	Female	Farmers	Agricultural experts	Teachers	Merchants	Others
Have you ever heard about the name fungi/mold	2.45	2.24	2.06	3.00	2.89	2.83	2.72
Have you heard of the word mycotoxins	1.32	1.23	1.15	2.58	1.56	1.30	1.34
Have you heard of the word Aflation	1.28	1.17	1.11	2.53	1.44	1.19	1.33
Have you heard of the word Ochratoxin	1.10	1.00	1.03	1.63	1.11	1.00	1.09
Have you heard of the word Fumonisins	1.15	1.11	1.08	1.74	1.28	1.09	1.17
Have you heard about mycotoxins occurrence in maize	1.61	1.68	1.48	2.79	1.89	1.94	1.55
Have you heard about mycotoxins occurrence in wheat	1.60	1.59	1.50	2.47	1.89	1.68	1.58
Do you know that mycotoxins can cause disease	2.31	2.10	1.97	2.84	2.56	2.45	2.62
Do you know that mycotoxins can cause stunting	1.84	1.79	1.72	2.37	2.28	1.92	1.86
Do you know that mycotoxins can cause cancer	1.70	1.76	1.56	2.37	1.94	1.85	1.82
Do you know that mycotoxins can suppress immunity	1.94	1.90	1.74	2.63	2.50	1.89	2.14
Do you know that mycotoxins can harm livestock	1.78	1.73	1.58	2.74	2.17	1.83	1.90
Do you know that mycotoxins survive cooking temperature	1.83	1.73	1.68	2.16	2.00	1.96	1.90
Do you know that mycotoxins accumulate in animal products	1.79	1.73	1.60	2.68	2.11	1.91	1.88
Do you know that the warehouse should be checked frequently	2.38	2.11	2.04	2.74	2.50	2.58	2.63
Do you know that cereals should be free from mites and insects	2.34	2.11	1.99	2.68	2.39	2.64	2.63
Do you know that mycotoxins can cause stomachache	2.30	2.00	1.92	2.95	2.61	2.36	2.61
Do you know that mycotoxins can cause headache	1.85	1.77	1.67	2.63	2.28	1.87	1.92
Do you know that mycotoxins can cause fever	1.80	1.78	1.67	2.42	2.11	1.81	1.89
Do you know that mycotxins can cause vomiting	2.00	1.87	1.76	2.58	2.28	2.08	1.89
Do you know that molds are harmful to human and animals	2.28	2.08	1.92	2.89	2.78	2.57	2.20
Mean	1.84	1.74	1.63	2.54	2.12	1.94	1.94

Comparison of mean knowledge level among the participants with various occupational types indicated that agricultural expertise has a higher knowledge level (2.54), and farmers have the lowest mean knowledge level (1.63) (Table 3). A significant difference in mean knowledge level ($P < 0.00$) was observed on the question related to fungi and their mycotoxins. Post hock test using kruskalmc test revealed the determining factors were higher education level and being an expert in the agricultural area. In this study, the knowledge level of respondents towards fungi and mycotoxin showed increasing with a better improved educational level (Figure 4). However, the difference in mean knowledge level is not statistically significant ($P > 0.05$).

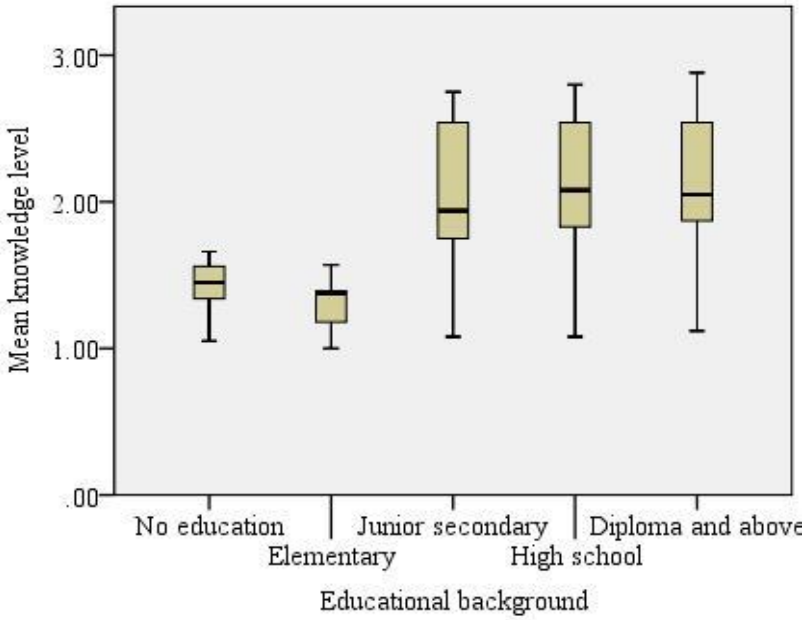

Figure 4. Median knowledge level of respondents by Educational background (Box = interquartile range, bold lines = median values, lower and upper hinges = lower and higher values).

3.3. Attitude of Respondents on Fungi Invasion and Mycotoxin

The attitude of respondents towards reducing fungal infection and mycotoxin contamination in wheat and maize was presented in Table 4. The overall mean attitude level of respondents (4.16) showed the participants had a favorable attitude towards fungal infection and mycotoxin contamination in wheat and maize. The highest and the lowest mean attitude level, 4.49 and 3.94 (Table 5) were obtained from teachers and elementary educational background, respectively. No significant differences in attitudinal levels was observed between male and female ($P > 0.77$), among occupation type ($P > 0.53$), and educational background ($P > 0.59$). The majority of the respondents (97.3%) had a favorable attitude in response to the first two questions synthesized to capture the attitude of the responses (Table 4). However, all respondents did believe in consuming or selling moldy wheat and maize. Additionally, all respondents had no favorable attitude towards testing maize and wheat for mycotoxin (Table 4).

Table 4. Attitude of respondents towards fungal infection and mycotoxin contamination in wheat and maize in four administrative zones of Oromia National Regional State during the 2018 cropping year.

Statements to capture respondents attitude	Responses											
	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		Mean	Standard deviation
	No.	%	No.	%	No.	%	No.	%	No.	%		
I believe cereals should be stored in dry and clean storage material	1	0.2	9	2.1	2	0.5	112	25.6	314	71.7	4.66	0.62
I believe that cereals should be transported appropriately packed and don't be re-wet	6	1.4	11	2.5	6	1.4	144	32.9	271	61.9	4.51	0.77
I believe that moldy cereals should not be consumed or soled	27	6.2	104	23.7	12	2.7	125	28.5	170	38.8	3.7	1.35
I believe that testing maize and whet for mycotoxin is important	47	10.7	37	8.4	28	6.4	184	42	142	32.4	3.77	1.28
Mean and Standard deviation											4.16	0.36

Note: *1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; and 5 = Strongly agree.*

Table 5. The attitude of respondents in relation to gender, occupation, and educational background in four administrative zones of Oromia National Regional State during the 2018 cropping year.

Statements to capture respondents attitude	Gender		Occupation					Educational background				
	Male	Female	Farmers	Agri. experts	Teachers	Merchants	Others	No education	Elem.	Junior	High school	Diploma and above
I believe cereals should be stored in dry and clean storage material	4.69	4.58	4.67	4.84	4.56	4.42	4.76	4.74	4.57	4.70	4.73	4.58
I believe that cereals should be transported appropriately packed and don't be re-wet	4.57	4.33	4.52	4.53	4.44	4.36	4.58	4.53	4.48	4.42	4.63	4.53
I believe that moldy cereals should not be consumed or soled consumed or soled	3.68	3.77	3.68	3.95	4.39	3.47	3.71	4.10	3.38	3.60	3.66	3.68
I believe that testing maize and whet for mycotoxin is important	3.78	3.75	3.60	4.21	4.56	3.89	3.87	3.69	3.34	3.66	3.90	4.08
Mean	4.18	4.11	4.12	4.38	4.49	4.03	4.23	4.27	3.94	4.10	4.23	4.22

3.4. Management Practice of Respondents towards Fungi Invasion and Mycotoxin

The result indicated in Table 6 showed the management practice of the respondent applied to minimize fungal invasion and mycotoxin contamination of wheat and maize. The overall mean management practice level of respondents towards reducing fungal infection and mycotoxin contamination was low (1.9) (Table 6). The mean practice level obtained for males (1.94) was slightly higher than the mean practice level obtained for females (1.84) (Table 7). However, there was no significant ($P > 0.05$) difference between the mean practice levels obtained for males and females.

Mean practice level to reduce fungal infection and mycotoxin contamination obtained for agricultural experts, merchants, teachers, and farmers were 2.35, 2.15, 2.13, and 1.73, respectively (Table 7). Comparison of mean practice levels based on occupation types showed significant ($P < 0.01$) differences among the various occupation types. Comparison of mean management practice levels base on the educational background (Figure 5), also showed significant differences among respondents with various educational backgrounds. The mean values of the practice levels were positively correlated with increasing education levels (Figure 5). The highest (2.2) and the lowest (1.34) mean practice levels were obtained for respondents with higher educational levels than diploma and elementary education levels respectively.

Table 6. Management practice of applied by respondent households to minimize fungal infection and mycotoxin contamination in wheat and maize.

Practice of respondents to reduce fungal infection	Responses						Mean	Standard deviation
	1(no)		2(not sure)		3(yes)			
	Number	%	Number	%	Number	%		
Protect wheat and maize from contamination by soil and animal excreta	160	36.5	101	23.1	177	40.4	2.04	0.88
Use moldy wheat and maize at home	259	59.1	142	32.4	37	8.4	1.49	0.65
Check quality before buying for visible mold overgrowth	111	25.3	87	19.9	240	54.8	2.29	0.85
Check regularly the storage for insect, rodents, and dampness at home or warehouse	94	21.5	115	26.3	229	52.3	1.97	0.80
Check the storage temperature	160	36.5	130	29.7	148	33.8	1.97	0.87
Use moldy grains for making traditional beverage/Tella/	231	52.7	119	27.2	88	20.1	1.67	0.79
Store inadequately dried grain	337	76.9	5	1.1	96	21.9	1.45	0.83
Place grains on bare soil ground	256	58.4	20	4.6	62	14.2	1.33	0.71
Keep wheat and maize in humid leaky soil	339	77.4	6	1.4	63	14.4	1.30	0.71
Eat foods with visible mold over growth	346	79.0	0	0.0	92	21.0	1.42	0.82
Early planting	182	41.6	58	13.2	198	45.2	2.20	0.95
Crop rotation	176	40.2	31	7.1	231	52.7	2.13	0.96
Proper soil nutrient management	183	41.8	44	10.0	221	50.5	2.06	0.95
Varity selection	190	43.4	31	7.1	217	49.5	2.06	0.96
Irrigation	294	67.1	79	18.0	65	14.8	1.48	0.74
insecticides	185	42.2	21	4.8	232	53.0	2.11	0.97
Timing of harvest	170	38.8	23	5.3	245	55.9	2.11	0.97
Hand sorting	189	43.2	41	9.4	208	47.5	2.17	0.96
Adequate/rapid drying	127	29.0	3	0.7	308	70.3	2.41	0.91
avoiding of floor contact	152	34.7	20	4.6	266	60.7	2.26	0.94
Rodent control	177	40.4	19	4.3	242	55.3	2.15	0.97
Winnowing	189	43.2	37	8.4	212	48.4	2.05	0.96
Mean and Standard deviation							1.91	0.10

Table 7. The practice of respondents to reduce fungal infection and mycotoxin contamination based on gender and occupation.

Practice of respondents to reduce fungal infection	Gender		Occupation				
	Male	Female	Farmers	AE	Teachers	Merchants	Others
Protect wheat and maize from contamination by soil and animal excreta	2.1	1.9	1.8	2.3	2.0	2.1	2.4
Use moldy wheat and maize at home	1.5	1.5	1.5	1.7	2.0	1.5	1.5
Check quality before buying for visible mold overgrowth	2.3	2.2	2.0	2.6	3.0	2.5	2.6
Check regularly the storage for insect, rodents, and dampness at home or warehouse	2.4	2.2	2.1	2.5	3.0	2.6	2.6
Check the storage temperature	2.0	1.9	1.9	2.1	2.0	2.1	2.1
Use moldy grains for making traditional beverage/Tella/	1.7	1.7	1.6	1.8	2.0	1.8	1.7
Store inadequately dried grain	1.4	1.6	1.4	1.9	1.0	1.8	1.4
Place grains on bare soil ground	1.3	1.3	1.2	1.8	1.0	1.5	1.3
Keep wheat and maize in humid leaky soil	1.3	1.4	1.2	2.0	1.0	1.6	1.3
Eat foods with visible mold overgrowth	1.4	1.4	1.3	1.6	1.0	1.5	1.6
Early planting	2.1	2.0	1.9	2.4	2.0	2.2	2.2
Crop rotation	2.2	2.0	1.9	2.6	2.0	2.3	2.4
Proper soil nutrient management	2.1	2.0	1.9	2.5	2.0	2.3	2.2
Varity selection	2.1	1.9	1.9	2.5	2.0	2.2	2.3
Irrigation	1.5	1.5	1.3	2.2	2.0	1.6	1.5
Insecticides	2.1	2.0	1.9	2.6	3.0	2.2	2.4
Timing of harvest	2.2	2.0	1.9	2.7	3.0	2.6	2.4
Hand sorting	2.1	2.0	1.8	2.7	2.0	2.5	2.1
Adequate/rapid drying	2.5	2.2	2.1	2.9	2.6	2.8	2.8
Avoiding of floor contact	2.3	2.2	2.0	2.8	3.0	2.7	2.5
Rodent control	2.2	2.0	1.9	2.8	3.0	2.4	2.5
Winnowing	2.1	1.9	1.8	2.5	2.0	2.4	2.2
Mean	1.9	1.9	1.7	2.4	2.1	2.2	2.1

Note: *AE = Agricultural experts.*

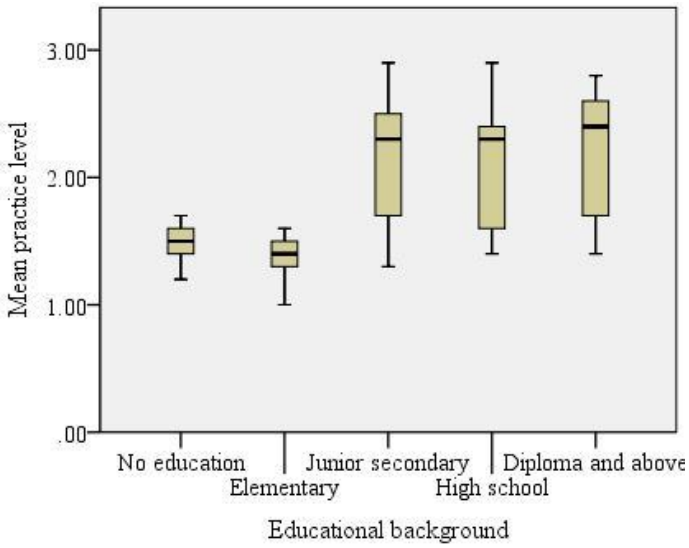

Figure 5. Management practice of respondents towards minimizing fungal infection and mycotoxin contamination in relation to the educational background (Box = interquartile range, bold lines = median values, lower and upper hinges = lower and higher values).

4. Discussion

The results of this study have demonstrated that the participants have a low mean knowledge level towards fungi and their mycotoxin. The majority of the respondents had little or no knowledge about the fungal invasion and their mycotoxins contamination in maize and wheat. This can be interpreted as a lack of awareness about fungi and their mycotoxin leads to a strong assumption that the community is at risk of fungal-derived mycotoxins. The result of this study is in line with the previous report from Malawi (Matumba *et al*., 2016) that revealed the lack of information on the health implication of fungal contamination and their mycotoxins in moldy foods and feedstuffs. A study from Malaysia (Sabran *et al*., 2012) also revealed a low level of respondents' knowledge regarding fungi and aflatoxin contamination in food commodities. A study by Matumba *et al*. (2016) showed that 98% of respondents were unaware of mycotoxin contamination in different fermented foods. However, the study reported by Mohd Azaman *et al*., 2016 indicated that a specific group of population linked with peanut-based productions has adequate knowledge, favorable attitude, and high hygiene practices towards aflatoxins contamination in peanut-based products with mean scores greater than average. It seems that most of the awareness creation activities in most parts of the world were associated with the risk of well-known aflatoxin contamination in peanut products (Mohd Azaman *et al*., 2016; Kibret Belayhun *et al*., 2019). The critical shortage of knowledge about fungi and mycotoxin underscores the need for awareness creation and education for the public in the study area.

Analysis of the socio-demographical background of the respondents showed a better understanding of fungal infection and their mycotoxins as educational level increase. The most vulnerable portion of the population was the least educated group with little or no knowledge of fungi and mycotoxins. Mycotoxin studies focusing on Africa highlighted that due to the poor socio-economic conditions, most Africans are forced to consume mycotoxin contaminated food products and subsequently suffer from related health complications (Geremew Teshome *et al*., 2016; Tola Marta and Kebede Bedaso, 2016; Haftom Kebede *et al*., 2020).

The overall mean attitude level of respondents (4.16) obtained in this finding showed that the participants had a favorable attitude towards fungal infection and mycotoxin contamination in wheat and maize. The lowest mean attitude level (3.7) was obtained for a statement "moldy cereals should not be consumed or sold" Table 4. This shows that regardless of their knowledge about fungi and mycotoxins, the respondents are consuming and/or selling moldy cereals implying that ignorance about the risk of consuming moldy cereals. This can be interpreted as an important area of intervention to change the attitude

of the respondents. The result didn't show any correlation of mean attitude level with an educational background or occupation (Table 5) and did not support the assumption "knowledge might influence awareness as well as attitude, and subsequently, behavioral action of individuals" (Mohd Azaman *et al*., 2016; Toh and Birchenough, 2000). This is an indication of the need for educational training intervention to farmers, agricultural experts, merchants, and another group of the community regarding fungi and their mycotoxins in Ethiopia. The previous report also revealed the positive impact of education and training to minimize the risks associated with consuming contaminated foods by fungi and mycotoxins (Matumba *et al*., 2016).

Analysis of mean management practice level towards reducing fungal infection and mycotoxin contamination based on educational background indicated that the mean practice levels obtained were generally low (1.9). Positive correlation of mean management practice level with increased education level (Figure 5) reveals the positive impact of increased educational level to alleviate the problem associated with fungal contamination and their mycotoxins. The result of this study was in agreement with the finding of earlier investigators who have reported a positive correlation of practice with a better educational background from different countries (Sanlier, 2009; Mohd Azaman *et al*., 2016).

5. Conclusion

The results of this study have revealed that knowledge about fungi and mycotoxin contamination is generally very low among farmers. This signals the need for providing training for farmers at all levels on toxin producing fungi and the danger of their mycotoxins present to humans and animals. Making all stakeholders aware about toxin producing fungi and their mycotoxins should be the primary intervention activity. Secondly, despite the favorable attitude obtained from the majority of the respondents, all respondents had an established perception that consuming or selling moldy wheat or maize is safe, which is a dangerous belief. Consumers have no information on safety the products they consume either. Therefore, research institutions, universities, health, and agricultural institutions should work towards changing this established perception, make people aware that there is a danger of consuming aflatoxins with moldy and ill-stored cereal grains. Third, the low mean practice level towards reducing fungal invasion and mycotoxin production in the wheat and maize grains suggests the community is at risk of mycotoxin health hazards. The analysis of knowledge, attitude, and practice obtained from teachers and agricultural experts showed higher level of ignorance of the less educated participants of the study than the more educated ones about the danger of consuming moldy cereal grains poses to health. This clearly shows that education is a key tool to minimize the likelihood of consuming or selling moldy cereal grains, which have finally contaminated with mycotoxins. Further studies need to be conducted in the future to elucidate the occurrence and consequences of mycotoxins in the various major staple cereal grains consumed in the country for developing management options to minimize health hazards.

6. Acknowledgments

Thanks are due to Adama Science and Technology University for funding the research.

7. References

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