Smallholder dairy farmers' knowledge, attitude and practices on aflatoxin contamination in feeds and milk: the case of Addis Ababa and Hawassa milk-sheds in Ethiopia

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Abstract

Following an alarming high aflatoxin contamination levels reported for animal feeds and milk in the greater Addis Ababa milk-shed of Ethiopia, livestock professionals, the regulatory bodies and public/consumers were alerted about the problem. However, whether farmers were also on the same level of concern was the main research question for this study. Therefore, this study was initiated to understand smallholder farmers' knowledge, attitudes, and practices regarding the causes, effects, and mitigation strategies of aflatoxins. The study applied a standard knowledge, attitude, and practices (KAP) measurement tool on market oriented smallholder dairy farmers from two milk sheds in Ethiopia. A total of 180 dairy producer households from the Addis Ababa milk shed (Sululta, Bishoftu and Adama) and Hawassa milk shed (Arsi-Negelle, Dore-Bafana and Kofele), Ethiopia, were interviewed using a pre-tested structured questionnaire. The results indicated that the average dairy cattle herd size in the study areas were 9.23 (±0.45). Sale of milk and dairy products is the major source of occupation/income to the large majority (78.3%), which shows that the selected dairy farmers were market oriented. Additionally, the majority of farmers (79.16%) owned higher cross dairy cattle (with >62.5% exotic blood/inheritance) while others have lower crosses (with <62.5% exotic blood/inheritance) and local cattle breed with 13.18% and 8.67%, respectively ($p < 0.05$). Overall, about 50% of the households have not received any training related to feed and milk safety/quality management as well as on how to handle and store it. From the total farmers, only 9.44% farmers know about the term aflatoxins, from this 90% do not know the causes/sources of aflatoxin and 96.6% do not know if it has any effect/impact on human/animal health. Most farmers (61.1 %) consume milk in its raw form. The study area is characterized by improved and market oriented dairy systems; however, farmers were less sensitized on the safety and quality requirements, notably related to aflatoxin contamination in feeds and milk. Although aflatoxin contamination has been a major concern in the dairy sector, particularly after the recent report on the Addis Ababa milk shed, the majorities of farmers remain unaware of its root causes and effects. Quite large proportion of farmers (93.3%) perceived that animal feeds are spoiled when molds are visibly observed and hence discard such feeds; it is highly probable that the non-observably contaminated feeds might go to dairy animals. Awareness creation campaigns and training programs on how to combat aflatoxins on farms needs to be developed before any other interventions.

Keywords: Aflatoxins; Attitude; Knowledge; Milk; Milk sheds; Ethiopia.

Introduction

Ethiopia has the largest livestock population in Africa. The cattle population in the country is estimated to be 66 million, out of which female cattle constitute about 57% (ESS, 2021/2022). About 97.4% of the total cattle are local breeds and the remaining are hybrid and exotic breeds.

Dairy development in Ethiopia holds large potential due to its large livestock population, the favourable climate conditions. Given the considerable potential for smallholder income and employment generation from high-value dairy products, the development of the dairy sector in Ethiopia can contribute significantly to poverty alleviation and the availability of foods (Ahmed *et al.*, 2004; Shapiro *et al.*, 2015; Dessie *et al.*, 2023). In the past few years, dairy is amongst the top 10 strategic agricultural commodities prioritized in the national development agenda of Ethiopia. Several strategies were proposed to develop the dairy sector in the unique and long standing Livestock Development Master Plan of Ethiopia (Shapiro *et al.*, 2015). In the recent four year development program/initiative called-*Yelmat Tirufat*, dairy was prioritized among the four livestock commodities to be developed, due to its potential roles in food security/family nutrition, economic development, job creation, and import substitutions (Dessie *et al.*, 2023). However, the sector is challenged by several factors which attribute to the low per capita milk production, low per capita consumption as well as the low safety/quality of milk and dairy products. In Ethiopia, food safety is recognized as important public health concern and hence a new national food safety master plan has been launched (FDRE, 2024).

The main livestock feed resources in Ethiopia are natural pastures, crop residues, improved forage crops, agro-industrial by-products, and nonconventional feeds (Chalchissa *et al.*, 2014). The availability of feed resources and their nutritional qualities are the most important factors that determine the productivity of livestock and production system. Bediye *et al.* (2018) indicated that the major constraints for the very low production and productivity of livestock in Ethiopia are the inadequate quantity of available feed and its poor quality. Most recently a safety and quality of some livestock feed resources are reported to have high rates of mycotoxins, contaminations of Aflatoxins in animal feeds and milk (Gizachew *et al.*, 2016).

Aflatoxins are a group of secondary fungal metabolites, so far known to be produced by nine different species of *Aspergillus* and two different *Emericella* species and are frequently found as contaminants in food and feed with adverse effects on humans and animal's health when ingested (Frisvad *et al.*, 2006). There are four main aflatoxin classes- AFB_1- aflatoxin B_1, AFB_2- aflatoxin B_2, AFG_1- aflatoxin G_1 and AFG_2- aflatoxin G_2 which have different environmental classified based on prolonged drought, humidity and temperatures, the composition of substrates, storage time and other crucial factors playing a significant role in the fungal synthesis of Aflatoxins (Stack and Carlson, 2003). The International Agency for Research on Cancer (IARC) has grouped AFB_1 under "group I" (Iqbal *et al.*, 2014) because of its high toxicity, teratogenicity, hepatocarcinogenicity and mutagenicity. AFM_1 occurs in the milk following ingestion of feed contaminated with AFB_1 by dairy cattle, which is partly converted to this hydroxylated metabolite and then excreted in milk (Prandini *et al.*, 2009). In 2012, the IARC further classified aflatoxin M_1 as "group I" based on its toxicity and carcinogenicity (IARC, 2012).

In Ethiopia, the prevalence of AFB_1, AFM_1, and other mycotoxins in feed and milk are reported as high. The alarming report of Gizachew *et al.* (2016) revealed aflatoxin-contaminated dairy animals' feeds and milk in the Greater Addis Ababa Milk Shed of Ethiopia's, notably showing alarming and detectable amounts of aflatoxins. In this report, feeds of dairy cows, notably nougcake to be a significant source of aflatoxin to the milk-shed. Since this report, the safety of Ethiopian milk in terms of mycotoxins has become a rising subject of concern (Amenu *et al.*, 2014; Gizachew *et al.*, 2016). Following this alarming high aflatoxin contaminations report in animal feeds and milk, livestock professionals, the media and regulatory bodies are alerted about the subject. However, whether farmers were on the same level of concern with the scientific/professional, regularity bodies and the public/consumers particularity in urban areas on aflatoxin causes, effects and its mitigation options was the main research question of this study. A misunderstanding and misconception of farmers on this problem might lead to low adoption rates of technologies and even can be a key barriers to any attempt to control/minimize aflatoxin contaminations in feeds and milk. Therefore, this study was initiated to understand the knowledge base, attitudes, and practices of smallholder dairy farmers on aflatoxin related issues, notably on the causes of mycotoxin, and its implication on animal and human health in particular; and also if they practice any control methods. The study applied a standard knowledge-, attitude-, and practices (KAP) measurement tool on market oriented smallholder dairy farmers from two milk sheds in Ethiopia, were the feed and milk handling, management and storage practices were investigated.

Material and methods

Study setting

This study was carried out into two major milk-sheds, which were purposively selected following previous reports of high aflatoxin prevalence in milk and animal feeds in the country. The two milk sheds are located in the central and the southern highlands of Ethiopia, where market oriented dairying prevails most. From the great Addis Ababa milk shed Bishoftu and Adama districts were selected, whereas from Hawassa milk-shed Kofele, Arsi Negelle and Dore-Bafana districts were selected (Figure1). The districts were selected based on their potential for milk production, market orientations, notably use of oil seed cake (i.e. cottonseed cake and nougcake) as main supplement feeds to dairy cows. In the selection process, agro-ecological diversities were considered, where Kebele selections considered the three main agro-ecologies (highland, mid-land and low-land).

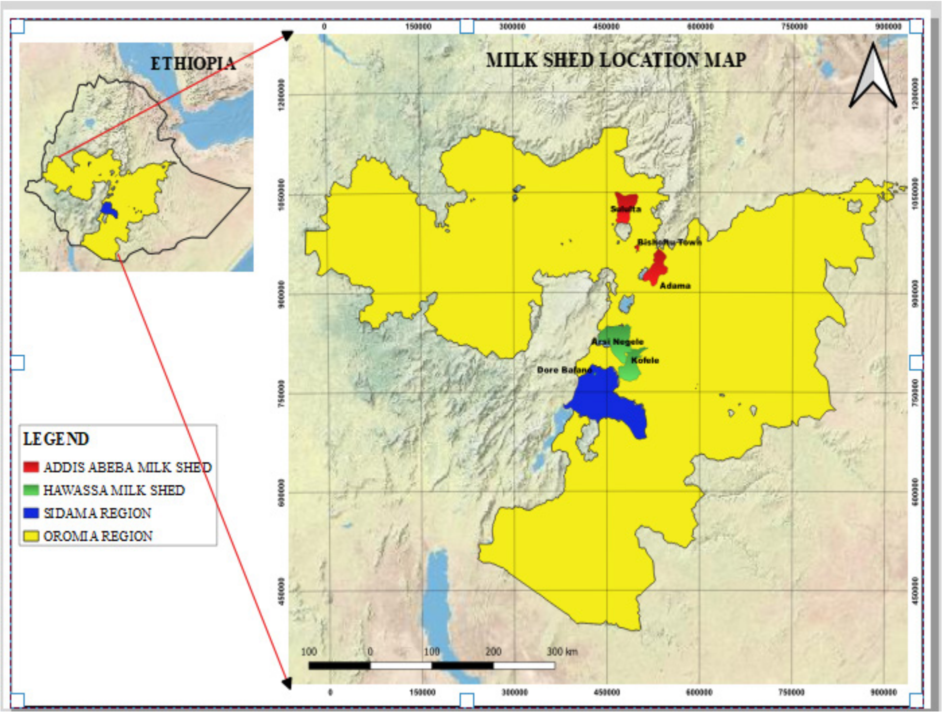

Figure1. Map of the study districts as reference to the two major milk sheds, the Hawassa and Addis Ababa milk-sheds.

Sample size and study subjects

The total number of interviewed households was 180, obtained through the formula adapted from Yamane (1967) as follows: $n = N/ 1 + (e)^2$, where N is the sampling frame for households who are market oriented (for inputs like feeds and outputs-like milk) and in particular those farms who feed dairy cows with oil seed cakes; e is the acceptable sampling error of 0.05 at the 95% confidence level. The target population of this study was households having lactating cows, households feeding oil-seed cake to dairy cows and farm-workers were considered eligible for the survey of the current study. As sampling distributions, half of the sample households n=90) were taken from each milk sheds, The sample households were disaggregated into small, medium and large scale dairy farms each having equal (n=60) households.

Sampling methods

A multi-stage sampling procedures were used, where the two milk sheds and five districts were purposively selected, the Kebeles were selected randomly from each agro-ecologies. From the selected Kebeles, farmers who fulfill, the selection criteria were listed and from the lists, randomization was applied to select the 180 farm households. Milk producing households data were obtained from the districts' agricultural and rural development offices. From each district, Kebeles representing the respective agro-ecologies were identified. One Kebele was selected randomly among the representative districts. In the second stage, from each Kebele, dairy producer households feeding oil-seed cake in the form of concentrate mix or in a separate way to their dairy cows were purposively identified. In the third stage, dairy producers were categorized into three groups based on the number of milking dairy cows kept as small (2-5), medium (6-10), and large (>10) as suggested by Ike et al. (2002). From each category 10 households who fulfilled the inclusion criteria were selected randomly for the survey, making the total number of households 30 from each Kebele and 90 per milk-shed. Individuals who were not willing to participate and accessible to the study were replaced with another eligible subject from the same Kebele.

Data collection procedures

A cross-sectional formal survey technique (ILCA, 1990) was employed to collect data from the dairy producers and workers through interviews, conducted in the local languages by the researcher using a pre-tested, structured questionnaire and personal observation. The study population's socio-economic characteristics, cattle size and herd structure, dairy cows feeding practices/system, and feed storage management practices as well as knowledge, attitude and practices of aflatoxin management in feeds and milk as well as perceptions of farmers on the health-related risks associated with aflatoxin contamination of milk and feeds were collected. In order to avoid scientific naming, we used the word '*shagata'* to mean 'molds' in feeds were used.

Data analysis

Data collected for the study were entered in Microsoft Excel and then exported to Statistical Package for Social Sciences (SPSS) software (version 20) for data analysis. Descriptive analysis was employed to obtain results, as means, frequency and per cent distribution of the assessed variables from the data set.

Chi-square (χ2) was used to determine significant differences among the different nonparametric variables. A probability value of less than 0.05 was considered statistically significant.

Results

Socioeconomic characteristics of the respondents

Table 1 below shows the age, sex, main occupation and educational status of household heads, as dairy farms were disaggregated by farm scales as small, medium and large. The overall mean household head age (±SE) was 43.97 (±1.42) years. Out of the total farms, 75.6% were male-headed with no significance difference ($p > 0.05$) between farm scales.

Table 1. Socioeconomic characteristics of the respondents in the study area (n=180).

Variables	Farm scale				
	Small (n=60)	**Medium (n=60)**	**Large (n=60)**	**Overall**	**χ2 (*p* value)**
Sex (%)					
Male	75	80	73.3	75.6	1.143 (0.56)
Female	25	20	26.7	24.4	
Occupation (%)					
Solely dairy farming	75	73.3	86.7	78.3	8.923 (0.17)
Government employee	5	3.3	6.7	5	
NGO employee	1.7	-	-	0.6	
Other private business	18.3	23.3	6.7	16.1	
Education (%)					
Non-formal*	11.7	16.7	13.3	13.9	
Primary School	60	46.7	45	50.6	10.422 (0.235)
Secondary school	26.7	28.3	35	30	
TVET/College	17	5		2.2	
Higher education/ University	-	3.3	6.7	3.3	
Age [mean (±SE)]	42.65±1.68	44.69±1.33	44.58±1.26	43.97±1.42	- (0.529)

* Some respondents are able to read and write, having learned through religious school or other means, which we used the term non- formal education rather than labeling them as illiterate.

Cattle size, breed and herd structure

Table 2 below shows cattle size, herd structure, breed type and also purpose of keeping cattle as disaggregated by farm scales. The number of lactating cows, pregnant cows and heifers were a significantly different ($p < 0.05$) between the three farm scale categories. The mean (SE±) total herd size in the study was 9.23 (±0.45). The proportion of lactating cows with 3.19 (±0.14) was higher than the rest cattle family, with 2.08±0.13 pregnant cows, 1.98±0.11 heifers and 1.81±0.17 dry cows.

Table 2. Average dairy cattle size and herd structure in small, medium and large scale farms in central highlands and southern part of Ethiopia (n=180).

Variables	Farming system				
	Small (n=60)	Medium (n=60)	Large (n=60)	Overall	*p* value
Herd size					
Mean (±SE)	4.01±0.11c	7.75±0.18b	15.97 ±0.76a	9.23±0.45	0.001
Herd structure: Mean (±SE)					
Lactating cow	1.83±0.09c	2.73±0.12b	5.0±0.27a	3.19±0.14	0.000
Dry cow	1.0±0.00c	1.43±0.13ab	2.44±0.33a	1.81±0.17	0.002
Pregnant cow	1.15±0.10b	1.65±0.14b	2.73±0.21a	2.08±0.13	0.001
Ox	1.00±0.00b	1.70±0.11a	2.23±0.20a	1.78±0.11	0.001
Young bull	1.09±0.09a	1.11±0.11a	1.51±0.15a	1.35±0.10	0.149
Heifer	1.09±0.06b	1.66±0.10b	2.64±0.21a	1.98±0.11	0.001
Male calves	1.25±0.11b	1.10±0.07b	2.0±0.18a	1.57±0.10	0.000
Female calves	1.17±0.07b	1.38±0.09b	2.25±0.14a	1.72±0.08	0.001
					$\chi 2$ (*p* value)
Cattle breed type (%) farms					
Local	3.73	6.70	8.67	7.64	20.23 (0.32)
Lower cross (< 62.5% exotic blood/ inheritance)	16.59	14.28	11.67	13.18	23.34 (0.135)
Higher cross (>62.5% exotic blood/ inheritance)	79.66	79.00	79.64	79.16	224.52 (0.000)
Purpose of keeping cattle (%)					
For selling and consumption	95.4	88.9	81.7	83.3	6.280 (0.393)
For milk selling only	4.6	11.1	13.3	15.6	
For calf production and selling	-	-	5	1.1	

SE: standard error

Type of feed resources used for dairy cattle

Table 3 shows the commonly used feed resources by dairy farmers in the study area.

Table 3. Type and source of feeds for dairy cattle in the study area.

Feed Resources	Milk-sheds				Total (n=180)
	Addis Ababa (n=90)		Hawassa (n=90)		
	Wet	Dry	Wet	Dry	
Green grasses	100	3.3	95.6	1.1	99.4
Hay	21.1	83.3	30	67.8	75.6
Silage	43.3	45.6	24.4	20	66.7
Molasses	93.3	94.4	80.9	91.1	91.1
Agroindustrial byproducts	94.4	86.7	91.1	84.4	89.2
*Commercial concentrate mix	95.6	94.4	93.3	92.2	93.9
Noug cake	5.5	4.6	2.5	1.9	3.7
Cottonseed cake	2.5	1.52	-	-	1.9
Brewery byproducts	45.6	52.2	71.1	66.7	58.9
Crop residue	66.7	82.2	76.7	96.7	71.7
Mineral Block	96.7	90	92.2	93.3	92.8
Source of feed					
Purchased	95.4	94.2	95.1	94.2	95.3
Own farm	3.5	2.4	4.8	2.7	3.9
Purchased and own farm	94.2	91.5	97.1	91.8	92.7

*Commercial concentrate mix (nougcake, cottonseed cake, grains, wheat bran)

Feeding troughs, feed store and barn management practices by farmers

Table 4 shows feeding feed storage and barn management practices by farmers in the study area. According to farmers' response, all farms (100%) practice regular cleaning of feeding troughs and feed storages. From the total households, only 30% households had received trainings on feed handling and storage management. Farmers are aware of the importance of udder/teat cleaning as well as stimulations at the time of milking.

Table 4. Feed storage management practices by farmers in the study areas (%).

Variables	Milk sheds		Total	χ2 (*p* value)
	Addis Ababa (*n*=90)	Hawassa (*n*=90)		
Feeding troughs and feed storage management				
Use feeding trough or manger, yes	100	100	100	
If feeding trough cleaned, yes	100	100	100	
Frequency of cleaning feeding trough				4.660 (0.097)
Once per day	61.1	75.6	68.3	
Every other day	33.3	22.2	27.8	
Twice per week	5.6	2.2	3.9	
Materials used to clean troughs				8.031 (0.005)
Brush with broom	41.1	62.2	51.7	
Brush with a broom and wash with cold water	58.9	37.8	48.3	
If feed storage rooms clean regularly, yes	100	100	100	
If you have separate feed storage rooms? yes	80	86	92.2	2.788 (0.095)
If attended any training on feed handling and storage?				
Yes	30	70	50	
No	70	30	50	
Frequency of cleaning feed storage rooms				18.940 (0.001)
Every day	55.6	71.11	63.3	
Once per week	18.9	23.3	21.1	
Every other week	4.5	4.5	4.4	
Every month	4.5	1.11	2.8	
Other	16.7	-	8.3	
Barn management				
Different groups of animals housed together, yes	45.6	15.6	30.6	19.087 (0.000)
Have separate milking parlor, yes	23.3	4.4	13.9	13.425 (0.000)
Wash udder before milking, yes	72.2	42.2	57.2	16.545 (0.000)
Dry the udder after washing, yes	92.2	94.4	93.3	0.357 (0.550)

Figure 2. Concentrate (A) and roughage (B) feed storage conditions by smallholder dairy farmers in the study areas.

Farmers' perceptions on aflatoxin and allied health threats

Table 5 shows the perceptions of farmers on aflatoxin and allied health threats in relation to their farm management practices. Only 9.4% of the farm households heard about the term aflatoxin.

Table 5. Perception of farmers on aflatoxin and allied health-related threats.

Variables	Milk sheds		Total	χ2 (*p* value)
	Addis Ababa (n=90)	Hawassa (n=90)		
If heard about aflatoxin				
Yes	12.2	6.7	9.4	5.262 (0.022)
No	87.8	93.3	90.6	
If it causes a problem for humans or animals				
Yes	4.4	2.2	3.3	35.483 (0.000)
No	95.6	97.8	96.7	
If source of aflatoxin known? yes	13	7	10	
If aflatoxin related illness exist?				
Yes	3.3	1.1		
No	96.7	98.9		
How to control the development of mold in the feed?				
Put the feed in well-ventilated place	81.1	94.4	87.8	10.423 (0.015)
By cleaning the store	10	1.1	5.6	
Ventilation and cleaning the store	7.8	2.2	5.7	
Ventilation and protection from moisture	1.1	2.2	1.7	
What to do with spoiled feeds?				8.929 (0.003)
Give it to animal	-	-	-	
Dump it	87.8	98.9	93.3	
Burn it	12.2	1.1	6.7	
Awareness of any type of milk-borne disease, Yes	24.4	6.7	15.6	10.827 (0.001)
State of consumption				
Raw	35.6	86.7	61.1	77.141 (0.000)
Boiled	58.9	-	29.4	
Raw fermented (Ergo)	3.3	12.2	7.8	
Boiled fermented (Yoghurt)	2.2	1.1	1.7	

Discussion

Characteristics of smallholder farmers

Education is an important mode to disperse information and knowledge to the public and is positively related to awareness, knowledge and perceived benefits (Jolly *et al*., 2009). Nambiro *et al*. (2006) observed that the literacy level of household members is associated with an increased likelihood of receiving extension services. In this study area, most of the respondents were literate, thus expected to easily accept and adopt novel technologies via various information sources and hence might have good knowledge of good dairy farm management practices. Quite large proportion of farmers in the study area have a fairly good educational status, which can be considered as a good opportunity/basis to arrange a training/advocacy platform that could acquaint farmers on the causes and effects of poor feed and milk handling practices on animal health and consumers (public health) safety, including on aflatoxin contamination prevention approaches.

Unlike the commonly reported higher compositions of oxen in a typical mixed crop-livestock systems, the present study revealed an overall high cow composition, shows how farmers are oriented towards milk production rather than considering cattle as a versatile functions. The fairly high compositions of cows have been reported as a good indicator, showing farmers production objectives and their orientations towards dairying and even market oriented dairy systems under smallholder conditions (Abate, 2007; Katongole *et al*., 2011).

The proportion of crossbred cows managed by farmers were quite high, with overall 79.16% owning crossbred cows (with >62.5% exotic blood/inheritance). Similar figures were reported by Bekele *et al*. (2019) for East Shoa Zone of Ethiopia, showing again how farmers are orientated toward milk production, which is mainly as income source. Yigrem *et al*. (2008) reported 57.8% of local breed cattle in the Shashemene–Dilla milk shed, which might attribute to the coverage of rural farms in the study and also due to the long years since the figure was reported. In all Ethiopian major milk sheds, there is a growing tendency of keeping improved breeds of dairy cows when they are becoming market oriented. Even though indigenous cows are low milk producers, they are still the major source of milk in the country at large. In this study, small scale farms were kept the lowest number of higher crossbreeds compared to large scale farms. By contrast, Haile (2011) reported that small size farms tend to keep relatively more exotic and crossbred cows than larger size farms.

The result of the current study indicated that 83.3% of households kept cattle for milk production- for home and sales, followed by 15.6% who produce solemnly for sale, and 1.1% for calf production and selling, again showing how farmers are becoming more market orientated. Similar studies indicated that 74.2% of dairy producers in the urban area of Hawassa city (Yigrem *et al*., 2008), and 68% of milk producers in the urban dairy system of northwestern Ethiopia (Ayenew *et al*., 2009) to produce milk primarily for sale.

Types of feeds and feeding management that exposes aflatoxin contamination

As commonly reported by many scholars for similar farming systems in Ethiopia (Bogale *et al*., 2008; Tolera, 2008; Yigrem *et al.,* 2008; Wondatir *et al*., 2011; Zeleke *et al*., 2016) natural grasses, grass or legume hay, silage, molasses, agro-industrial by-products, concentration mix (including nougcake, cottonseed cake, grains, and wheat bran), crop residues and brewery by-products were identified as major feed resources.

The majority (95.3 %) of the farmers bought supplementary as well as roughage feeds from the market, while only 3.9 % used feed from own farms. This is a common practice in landless systems, urban dairy producers in the country, where dairy producers relay on purchased roughages as well as concentrate feeds (Yigrem *et al*., 2008), and is very difficult to trace/track the main and original sources of contaminants to feeds. However, according to farmers, feed availability and prices change over seasons, and hence farmers usually buy bulks of concentrate and roughage feeds and store it for long time, which might exacerbate quality deteriorations. The fluctuations in the seasonal availability are mainly associated with the rainfall distribution and cropping seasons for food-feed crops. According to studies, aflatoxin levels rise with storage time in hot and humid environments, and hence such feed resources stored in farms are more vulnerable due to the combination of heat and moisture that promotes the growth of common mycotoxin producers *Aspergillus* and *Fusarium* (Villers, 2014).

According to farmers' response, all farms (100%) practice regular cleaning of feeding troughs and feed storages. The cleaning practice reported by farmers could not warrant the actual conditions of the feeding troughs and stores, as the way/level of cleaning and ventilation of the feed storage rooms as well as feeding troughs are crucial to reduction of contaminations with aflatoxin in feeds. Adequate storage conditions with optimal moisture, temperature, and aeration are vital for the prevention of aflatoxin contamination in feed stores (WHO, 2018). As shown in Figure 2 (B), crop residues are stored without shelter and supplement feeds are stored in conditions which might cause spoilage of feed, especially in the rainy season, as observed in the top view, the feed resource has changed colour. Therefore, the quality of feed has deteriorated in the mode of storage, aflatoxins might easily develop as well as result significant wastage of feed resources due to visible molds observed by the wrong modes of storages.

In this study, 30.6% of farmers housed their dairy cows together with other classes of animals (heifer and calves), where there was a significant difference ($p < 0.05$) between the two milk sheds, where the condition in the Hawassa milk shed was better. Improper barn cleaning practices and herd management could expose sensitive animals like calves to be exposed to pathogens such as *Escherichia coli*, rotavirus, coronavirus, or *Cryptosporidium,* and fungi (Bartels *et al*., 2010). This would further exacerbate exposures of pathogens and toxins to feeds and milk (Broucek *et al*., 2017). Good udder management practices further helps to reduce contaminations of milk to such pathogens and their toxins that comes from barn, feeds and feces. Milk bacterial spores most likely originated from fecal, feed and feaces could enter to the teats at the time of milking. Magnusson *et al.* (2006) also showed that teat cleaning reduced the milk spore content by 96%. A good pre-milking hygiene routine can decrease the cow infection ratio by not only reducing udder bacterial and fungal contamination from the environment but also from other infected animals (Grindal, 1989).

Overall, about 50% of the households have not received any training related to feed handling and storage. When compared between the two milk sheds, a very lower proportion, about 30% of the household, the Hawassa milk shed had received more training/s. Trainings on how to handle feed storage and proper storage mechanisms of the feed including and awareness creation on feed storage conditions were found to reduce fungal-producing mycotoxin in farms (Atukwase *et al*., 2012). According to Atukwase *et al*. (2012) in their studies in Uganda, simple and traditional storage structures can be used to reduce Fusarium incidence in maize, and the study concluded that maintaining the moisture contents of maize below 14% was highly recommended. The same might be applied for animal feeds, where reducing moisture contents in feed storage sites should be highly encouraged to dairy farmers. Hell and Mutegi

(2011) also suggested various post-harvest interventions that help reduce aflatoxin in food-feed crop which are applicable in Sub-Saharan contexts; recommendations included proper transportation and packaging, proper drying process (sun-drying being most suitable), sorting, cleaning, smoking as well as use of pesticides as storage protectants. Further context specific studies might be required to have feed type specific recommendations.

Farmers' knowledge, attitudes and practices on aflatoxin management

In our study only 9.4% of the farm households heard about the term aflatoxin. However, from randomly interviewed feed processors, all were aware of aflatoxins, their causative agents and hence they work on proper feed management and handling. Some feed processors used aflatoxin binders in their feeds, which is a scientifically proven technology. A study in the Wolaita zone of Ethiopia also reported a very small proportion of dairy farmers who were aware of aflatoxin and its consequences (Kibret *et al.*, 2019). Awuah *et al.* (2009) and Jolly *et al.* (2009) also reported very low levels of awareness of farmers about aflatoxin contaminations in food/feeds in Ghana, with 10% and 8%, respectively. Some studies like Marechera and Ndwiga (2014) in Kenya reported 93%, and others like Kamala *et al.* (2016) in Tanzania reported 20% who were aware about aflatoxins. The current study looks to show very low level of awareness of farmers on aflatoxin, if one considers the time span and the hot debate the dairy sector had after the recently released report of Gizachew *et al.* (2016) which showed high levels of aflatoxin contents in milk/feeds for the Addis Abeba milk shed, which was followed by high levels of public debate even on public and social medias. Studies on the prevalence of aflatoxin in feed and milk, the toxin epidemiological survey and feed handling and storage are very limited, therefore this might lead to dairy farmers' having low awareness of mycotoxin/aflatoxin contamination of the feed and milk. The high levels of farmers awareness about aflatoxin in Kenya, might attribute to epidemiological events of aflatoxicosis that killed several people (Probst *et al.*, 2007). Such media campaigns contribute a lot to awareness of the public, notably consumers and also farmers.

Globally aflatoxins contaminations are commonly reported for foods such as peanuts, grain, legumes, and corn. They are known a carcinogenic agent in experimental animal models and aflatoxin B1 (AFB1) is the most potent hepatocarcinogen (Sharma *et al.*, 2004). Worldwide AFB1 is well-known to have a range of biological activities, including acute toxicity, teratogenicity, mutagencity and carcinogenicity. AFB1 exposure correlates with a specific mutation at codon 249 in the p53 tumor suppressor gene in liver tumors and suggested the interaction of aflatoxins with hepatitis B virus infection in the development of hepatocellular carcinoma (Hamid *et al*., 2013).

In the present study, among the ones that have heard about aflatoxin, 96.6% of them said they do not know if it has a threat to human or animal health and 90% farmers do not know its sources. About 30% of the respondents in Addis milk shed and 15% of the respondents in Hawassa milk shed were aware of milk-borne diseases. Among the respondents that said know that milk can cause disease, about 1% of the respondent in Hawassa milk shed and 3% of the respondents from Addis Ababa milk-shed reported they know milk can cause aflatoxin related illness. Still quit large proportion of farmers (61.1%) and their families consume raw milk, while 29.4%, 7.8% and 1.7% farm households consumed only after boiling, as fermented milk (Ergo) and boiled fermented (yoghurt) states, respectively. Fermentations of dairy product have shown to reduce aflatoxin M1 (Harshitha *et al*., 2024).

About 85% of households feel they store feeds in a well-ventilated stores and inhibit/control the development of molds in the feed. Quite large proportion of farmers (93.3%) responded that if feeds are visibly spoiled with molds, they dump it rather than feeding their animals. However, if molds are not visibly contaminating feeds, it is highly probable that it might go to their animals.

Conclusions

The study area has a typical market oriented dairy cattle production systems with improved cattle management practices, high proportions of crossbred dairy cows and high proportion of lactating cows, and substantial use of non-farm/purchased feed resources. The farming system is sensitive to input and output markets as well as those factors which affect markets, like feed/milk contaminants. Even if aflatoxin issues were a hot issue to the dairy sector, especially after the recent report by Gizachew *et al*. (2016), the majority of dairy farmers have never heard of aflatoxins, and are unaware of whether it poses any health threat to animal health or public/consumers. The scientific and regularity bodies as well as the wide public, particularly dairy consumers in major cities, might know the alarming news about aflatoxin and its consequences. However, if dairy farmers who are the main sources and harbors of aflatoxin contaminations (in feeds and milk), are unaware of this hot discussions, and if they are not well acquainted on the root causes, impacts/effect of aflatoxins and apply various mitigation strategies, any interventions that is intended to reduce the impacts of such unsafe animal source food products in the markets could not be successful. Most importantly, quite large proportion of farmers (93.3%) perceived that animal feeds are spoiled when molds are visibly observed, which they dump it rather than feeding to their animals which is regarded as a good practice. However, if molds are not visibly contaminating feeds, it is highly probable that the contaminated feeds might go to dairy animals. Therefore, awareness campaigns and training programs on aflatoxin management are crucial for effective mitigation.

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Conflict of interest

The authors declare that they have no competing interests.

Ethics approval and consent to participate

Participation of farmers for the survey was fully voluntary and informed consent was obtained from all involved in the study. The study didn't require a special ethical approval as we didn't have sensitive animal/human/environmental subjects.

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