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Vol. 11(39), pp. 3741-3750, 29 September, 2016
DOI: 10.5897/AJAR2016.11525
Article Number: C31B56560820
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Association of on-farm feeds handling practices with fungal growth and Mycotoxin production on feeds in smallholder dairy farms, Nakuru, Kenya

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Received 4 August, 2016; Accepted 1 September, 2016

Practices used by smallholder dairy farmers for handling of feeds at the farm pose a risk of mycotoxins to dairy animals and dairy products, hence a public health concern. The aim of the study was to document the on-farm practices of handling feeds used by these farmers and how they influence the growth of mycotoxin producing fungi together with prevailing extrinsic conditions. Study involved the use of structured questionnaire for interview of smallholder dairy farmers (n=120) for on-farm feed handling practices and collection of feed samples (n=97) for microbial analysis of the mycotoxin producing molds. The fungi counts were interrelated with the feed handling practice and therefore a measure of its impact. Results found out that rural dairy system was characterized by practice of free range grazing unlike peri-urban system practice that had semi-intensive stall feeding. At the farm level, the type feeds storage facility and the type and condition of feeds were found to be significant risk factors (p<0.05) for infestation of mycotoxic fungi. Feed contamination on farm at the sub-value chains with mycotoxic fungi is primarily due to poor storage facilities exposing feed to environmental conditions that favors fungi growth.

Key words: Feeds, fungi, mycotoxins, *Aspergillus, Fusarium,* Kenyan smallholder farmers.

INTRODUCTION

Smallholder dairying is dependent on stall feeding, using cultivated fodder and crop residues. Due to feed shortages for cattle during the dry seasons, farmers do either store feeds during the rainy season for later consumption or buy forage, silage and concentrates from agrovet shops. Poor quality dairy feed serve as a carrier for pathogenic fungal species. Fungus can affect feeds quality by reducing dry matter, nutrients, causing musty or sour flavour, caking of feed and important production of mycotoxins (Maciorowski, 2002). Mycotoxins are

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secondary metabolites produced by saprophytic fungi that grow on substrates kept under conditions that favor the toxins production (Sertova, 2015).

Mycotoxin production can occur when favorable conditions are met that allow fungi to grow on crops in the field, at harvest, in storage or during the processing of feed (Iheshiulor et al., 2011). These conditions for mycotoxin biosynthesis are both, physical and chemical of the substrate. The physical conditions include temperature, relative humidity and presence of oxygen while chemical conditions include pH, water activity (a_w) and nutrients among others (Dagnas and Membré, 2013). In East Africa, the hot and humid climatic environmental conditions favor and mycotoxin production (Wagacha and Muthomi, 2008). Consumption of contaminated feeds exposes dairy cows to the risk of mycotoxicosis. The fungal genera associated with mycotoxin production includes *Aspergillus* and *Fusarium* among others (Richard and Bullerman, 2007; Iheshiulor et al., 2011).

Small scale dairy farmers in Kenya lack best animal feed production and management practices (Lukuyu et al., 2011). The methods and handling practices of on-farm feed formulations at rural and peri-urban dairy sub-value chains are likely to act as risks to the occurrence of mycotoxins by creating conditions conducive to fungal growth. Therefore the aim of this study was to document these on-farm feeds handling practices and relate to occurrence of common mycotoxin producing fungals in the feeds. The data from this study can be used to inform stakeholders in the dairy industry of Kenya during developing of intervention mechanisms of reducing mycotoxins contaminations in milk.

MATERIALS AND METHODS

Study area

The study was carried out in three divisions in Nakuru County, Kenya namely; Bahati, Olenguruone, and Dundori. Olenguruone division represented rural dairy system and lies at 35° 40’60”E and 0° 34’60”Sin DMS (degree minute seconds) while Bahati and Dundori divisions represented peri-urban dairy system and lie at 36° 16′ 12″ E and 0° 12′ 0″ S. Nakuru county is located 160 km North West of Nairobi. Nakuru County where the divisions are found covers a total area of 1036.5 km^2 and has 52,670 small scale farms with a population density of 35,500 dairy cows, 20,500 zebu (*Bos indicus*) and 15,000 exotic dairy cattle (*Bos Taurus)*.

Study design and data collection

A cross sectional study was carried out in Nakuru County, Kenya between March 2015 and October 2015. The study units were individual farms and agrovet shops that were directly involved in farm feed formulations and handling of feeds. In rural dairy system a total of 78 respondents were interviewed while in peri-urban system a total of 42 respondents were interviewed. Respondents were interviewed to collect information on type of feed handling practices employed at farm level. Key elements of the questionnaire included socio-economic aspects, farm intensification characteristics and farm management practices that influence mycotoxin contamination of feed. Animal feed samples were also collected into sterile plastic bags and transported within 24 h to the Egerton University laboratory for analysis. Data was also obtained through critical observations of practices, personnel actions and key informant discussion during the sampling.

Sample analysis

Determination of environmental temperature, environmental humidity, and temperature and humidity inside storage feeds bags

Voltcraft, Lindenweg 15, D-92242 Hischau/Germany 4 in 1 digital multimeter with a humidity probe and temperature probe was used to measure environmental temperature and environmental humidity of animal feed stores on the farms. This was done according to the manufacturer’s instructions.

Fungi isolation and identification

Five-fold serial dilution of 10 g of feed with 90 ml peptone water then 0.1 ml of the dilution was cultured by spread plate technique into Potato dextrose agar (PDA) supplemented with chloramphenicol at 40 µg/ml and Gentamycin at 500 µg/ml and incubated for 5 to 14 days at 25°C. Pure culture of the different colonies (based on morphology) was obtained by sub-culture of the isolates on potato dextrose agar (PDA) plates and sabouraud’s dextrose agar plates. The fungal isolates were identified to the genus/species level based on macroscopic and microscopic characteristics of the isolates obtained from pure cultures (Islam et al., 2014).

Statistical analysis

Data obtained from the on-farm animal feeding practices were analyzed by means of general descriptive statistics and chi-square test for determination of independence using SPSS version 20 (IBM Corp.) Data obtained from fungal counts was transformed to $\log_{10}$ colony forming unit per gram (cfu/g) before analysis. This Logarithmic transformation was applied to the fungal counts data to meet the assumptions of analysis of variance (ANOVA) and was tested for normality using Komolgorov–Smirnoff's test while the homogeneity of variances was tested using the Levene's test (Goberna et al., 2005). The microbiological data and environmental factors data were analyzed for analysis of variance (ANOVA) using General Linear Model procedure (PROC GLM) of SAS version 9.1.3 (Cary NC: SAS Institute Inc). Means comparisons were done using Least Significant Differences (LSD) method at the 95% confidence level.

RESULTS

Farmers’ on-farm practices influencing fungal and mycotoxin contamination of feeds

The intensification type’s dairy farming as practiced by smallholder dairy farmers between the two dairy systems are shown in Table 1. It was found that 75% (59/78) of smallholder farmers in the rural system practice free range type of intensification while 93% (39/42) of the smallholder farmers in the peri-urban practice either

Table 1. The intensification types practiced by smallholder farmers between the two dairy systems.

	Dairy system		
Intensification type	**Rural (n=78)**	**Peri-urban (n=42)**	**Overall (n=120)**
Zero-grazing (%)	2	29	15
Semi zero-grazing (%)	23	64	43
Free range (%)	75	7	42

Table 2. Practices used by smallholder in rural and peri-urban dairy systems related to the feeds handling and animal feeding.

Feed handling practices and associated risk factors	Dairy system		
	Rural (n=78)	**Peri-urban (n=42)**	**Overall (n=120)**
Type of feed given to dairy cows (%)			
1. Commercial dairy meal	7	7	7
2. Pasture and Napier	66	7	37
3. Commercial dairy meal, Pasture and crop residues	14	57	35
Source of commercial dairy meal (%)			
1. Cooperative agrovet	96	0	49
2. Local retail agrovet	0	100	50
Supplementation using dairy meal (%)			
1. Purchased dairy meal formulation	30	86	57
2. Homemade dairy meal formulation	0	7	4
Feed storage facilities (%)			
1. In stores	68	64	66
2. In a store, on the floor and humid	2	21	12
3. In a store, raised rack and dry	5	14	9
4. On open raised rack and humid	11	0	6
5. No storage facilities	10	0	10
Training on silage making (%)			
1. Farmers practicing silage making	20	14	17
2. Trained farmers on silage making	41	21	31
Practices to obtain aerobic stable fermented silage (%)			
1. Proper sealing once silage is removed from silo	9	7	8
2. Proper silo wall management	7	7	7
Awareness of mycotoxin contamination (%)			
1. Routine checking of fungal growth in animal feeds	34	64	45
2. Knowledge on aflatoxicosis in dairy cows	30	68	49

exclusive zero-grazing or semi-zero grazing type of intensification (Table 1). Farmers' on-farm practices influencing fungal and contamination of animal feed in rural and peri-urban dairy systems is shown on Table 2. As a result of different intensification types among the systems, the practices on types of feeds used and use of the supplementation with dairy meal was also found to be different among the two dairy systems as shown in Table 2.

The environmental factors affecting growth of mycotoxigenic fungi in feeds

The rural dairy system had a mean environmental temperature of 16.60±1.0°C while peri-urban dairy system had a mean environmental temperature of 15.96±1.5°C (Figure 2). In addition, the mean temperatures in the feeds storage bags were not significantly different between the two dairy systems. Rural system was found have a mean storage bag temperature of 16.60±1.0°C while peri-urban had a mean storage bag temperature of 15.96±1.5°C. Therefore it was established that there are a very strong relationship between environmental temperature and the feeds storage bag temperature which are very strongly correlated ($r=0.999$, $p<0.001$, Table 3).

It was found out that the mean environmental humidity were significantly different between the two dairy systems (Figure 3). Rural system was found have a mean environmental humidity of 37.77±0.8% while peri-urban had a mean humidity of 36.90±0.9% (Figure 3). Also,

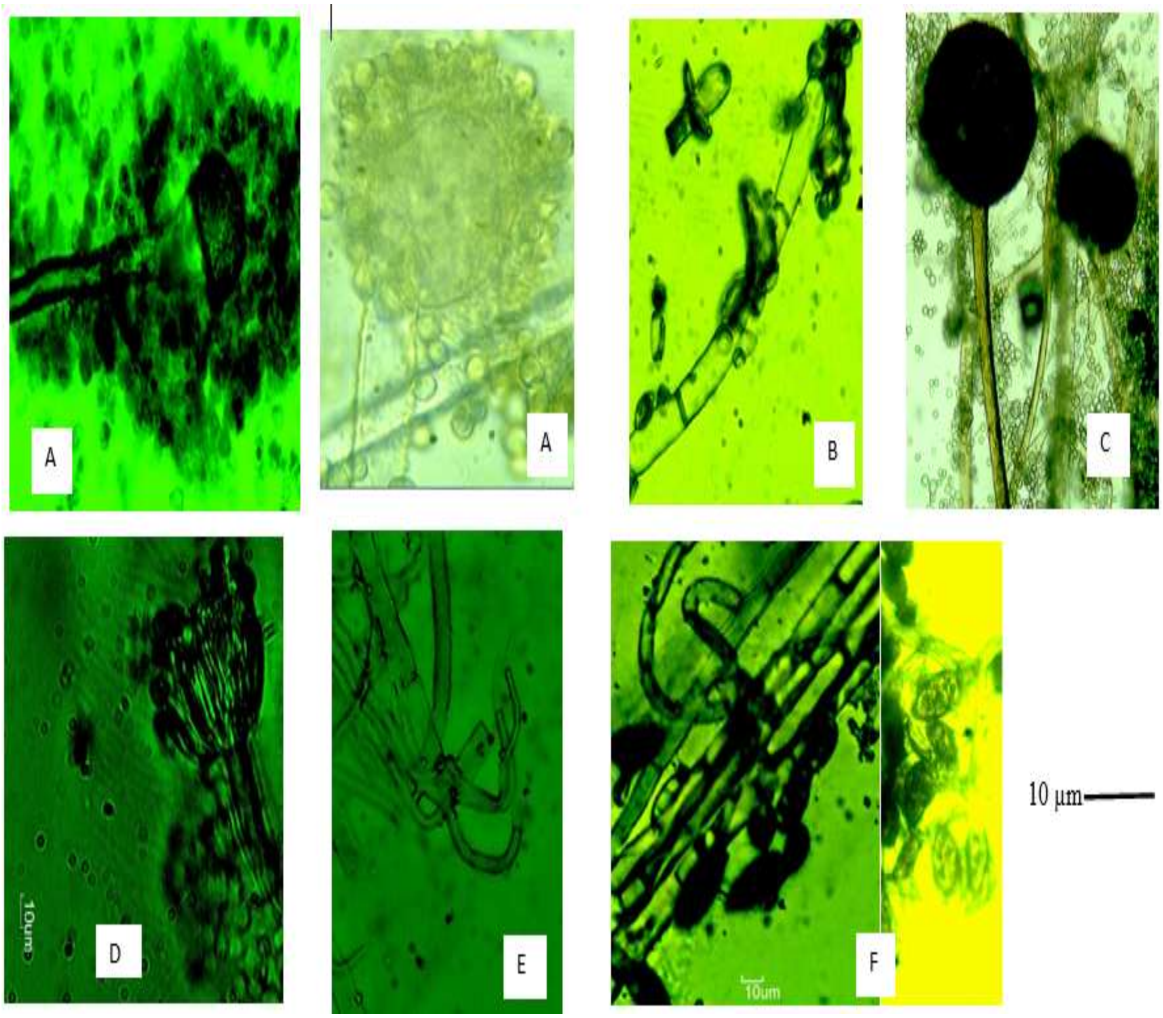

Figure 1. Different fungal species at ×100 magnification isolated from animal feeds. Where A= *Aspergillus*; B=*Cladosporium*; C=*Mucor*; D= *penicillium*; E= *Fusarium* and F= *Alternaria.*

there exists a strong relationship between environmental humidity and storage bag humidity which were found to be strongly correlated (r=0.799, p<0.001 - Table 3). Rural system had 2.4 and 3.5% higher environmental and storage bag temperatures respectively than peri-urban. High average humidity levels were noted in silage silos of 72.00±0.6%.

Fungal count, isolation and identification in feed samples as indicator of risk factors for mycotoxins

The mean count of fungal growth in feeds was significantly different between the two dairy systems p≤0.05 (Figure 4). Concentrates had the highest fungal count of $\log_{10}$ 4.92 ±0.4 cfu/g as compared to $\log_{10}$ 3.99±0.9 cfu/g forages (Figure 4). The dominant toxigenic fungi genera in both dairy systems were *Aspergillus* spp*.* 77%*,* and *Fusarium* spp. 70% respectively (Table 4). Microscopic monographs showing different fungal species were used for identification (Figure 1).

The risk factors associated with the prevalence of fungal in feeds

At the farm level, the type feeds storage facility and the type and condition of feeds were found to be significant risk factors (p<0.05) for infestation of mycotoxigenic fungi while the type of the dairy system, the source of feeds and any training on feed formulation and handling were found to present no significant risk factors (p>0.05) for infestation of mycotoxigenic fungi (Table 5).

DISCUSSION

The study identified three risk factors for mycotoxin

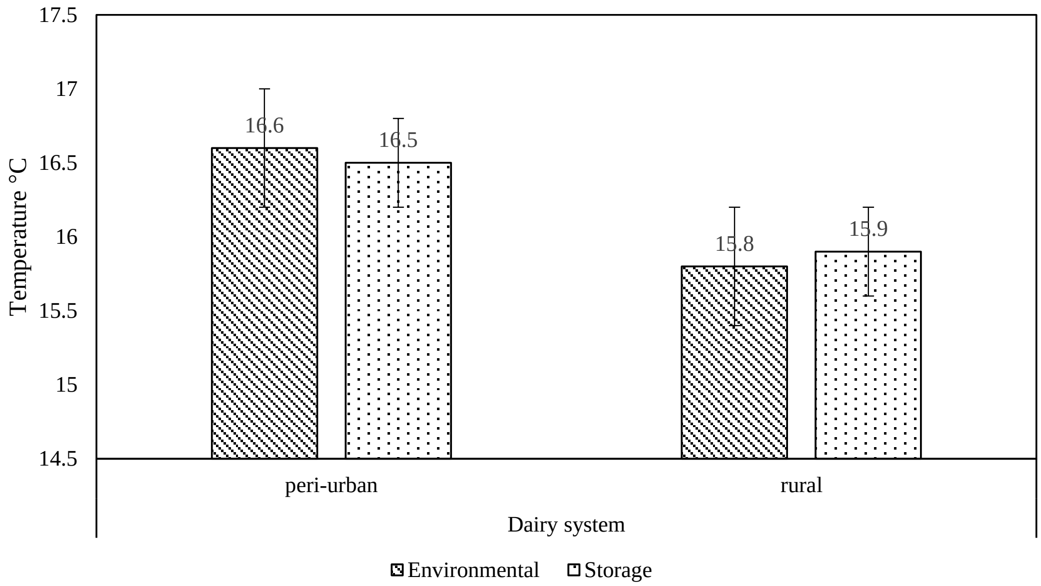

Figure 2. Environmental and storage temperatures prevailing in the dairy systems.

Table 3. Correlation coefficients among different environmental parameters, physico chemical parameters and microbial counts.

	StoreTemp	EnvTemp	StoreHum	EnvHum	TVC	MC
StoreTemp	___	0.999***	-0.618***	-0.179	0.013	0.0002
EnvTem	___	___	-0.618***	-0.179	0.015	0.002
StoreHum	___	___	___	0.799***	-0.122	-0.111
EnvHum	___	___	___	___	-0.421	-0.158
TVC	___	___	___	___	___	0.881***
MC	___	___	___	___	___	___

StoTemp = storage bag temperature; Envtemp = environment temperature; Stohum = storage bag humidity; envhum = environmental humidity; TVC=total viable counts; MC= fungal counts, * is significant at P<0.05, ** is significant at P<0.01 and *** is significant P<0.001.

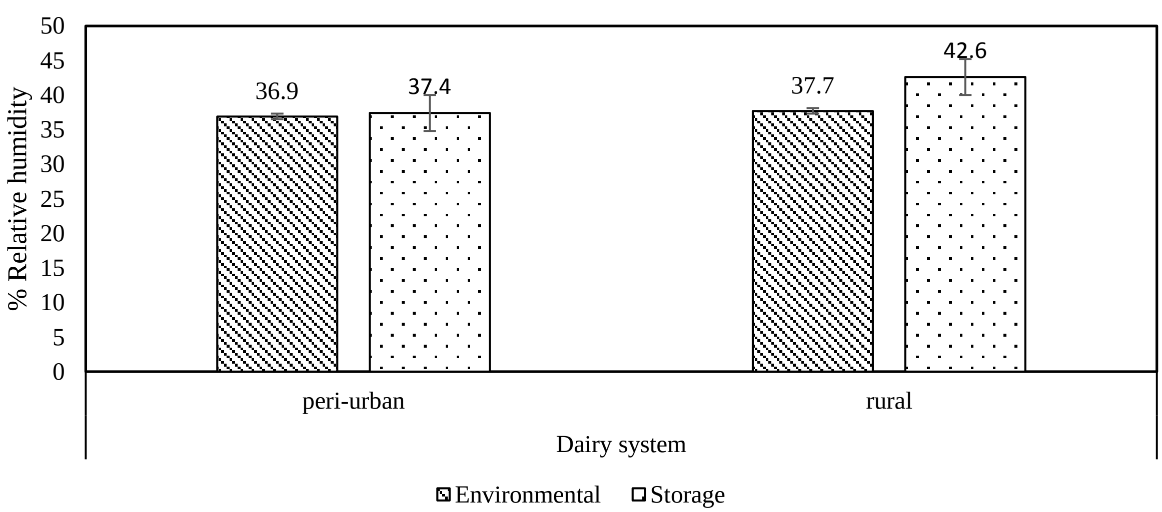

Figure 3. Environmental and storage humidity prevailing in the dairy systems.

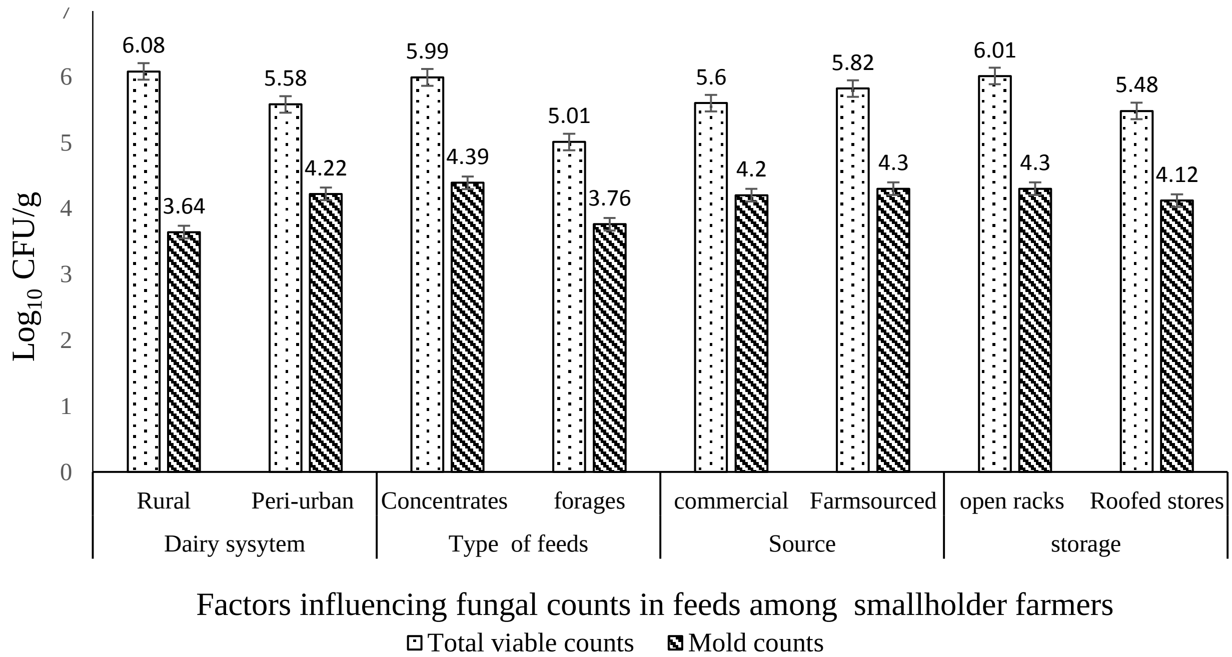

Figure 4. Mean count of fungal growth in feeds.

Table 4. The prevalence of fungi in feeds from the two dairy systems.

Fungal genera	Number of samples			Frequency (%)		
	Rural (n= 57)	Peri-urban (n= 40)	Overall (n=97)	Rural	Peri-urban	Overall
Aspergillus	45	30	75	79	75	77
Fusarium	42	26	68	74	65	70
Cladosporium	13	12	25	23	40	26
Mucor	16	13	29	28	33	29
Penicillium	1	2	3	2	15	3
Alternaria	3	2	5	5	5	5

contamination at the farm level; the type of feeds, type of storage facility and the type and condition of feeds were found to be significant risk factors ($p<0.05$) for infestation of mycotoxigenic Fungi, while the type of the dairy system, the source of feeds and any training on feed formulation and handling were found to present no significant risk factors ($p>0.05$) for infestation of mycotoxigenic fungi (Table 2). Feeds can be contaminated during pre-harvest and therefore control of additional fungal growth and mycotoxin formation is dependent on storage management. After harvesting, temperature, moisture content and insect damage are major factors influencing mycotoxin contamination of feed grains and foods (Krnjaja et al., 2011).

The type of feeds was found to be significant risk factor ($p<0.05$) for infestation of mycotoxigenic fungi. Dry Concentrates had the highest fungi count of 4.39±1.0 cfu/g as compared to 3.76±1.0 cfu/g in wet forages (Figure 4). The dominant toxigenic fungi genera in both dairy systems were *Aspergillus* spp. 77%, and *Fusarium* spp. 70%, respectively (Table 4). This was attributed by different extrinsic and intrinsic factors affecting the different types of feeds. Mycotoxin producing fungi establishment, development and subsequent mycotoxins production in feeds depended on extrinsic abiotic factors that were temperature, pH, water activity and gaseous composition of the surrounding atmosphere. Intrinsic factors were chemical composition of feed which had an influence on growth and mycotoxin biosynthesis. The moisture in feeds determined fungi colonization of concentrates or forages by enabling them to breakdown complex macromolecular compounds and utilize them for metabolism, growth and eventually mycotoxin production (Oyeka and Kushwaha, 2004).

The type of storage facility was found to be significant risk factors ($p<0.05$) for infestation of mycotoxigenic

Table 5. Feeds types and feed handling practices influencing mycotoxin fungal and mycotoxin contamination of feed in rural and peri-urban dairy systems.

Factors		Fungi infested feeds	Fungi free feeds	Prevalence (%)	Prevalence Ratio	p-Value
Dairy system	Peri-urban	30	10	75.0	χ^2 =60.809*	0.650
	Rural	45	12	78.9		
Storage	Enclosed stores	24	28	53.8	1.78	0.040
	On open racks	43	2	95.6		
Source of feeds	On-farm formulation	55	25	68.8	1.28	0.144
	Bought from agrovets	15	2	88.2		
Types of animal feed	Concentrate	50	7	87.7	2.34	0.032
	Forages	15	25	37.5		
Any training on feed formation and handling	Yes	27	10	72.9	1.23	0.087
	No	52	6	89.7		
Condition of feeds	Dry	50	7	87.7	2.34	0.011
	Wet	15	25	37.5		

fungi. Farmers' mostly stored feeds under open structures (Table 2). Feeds stored in open structures had the fungal count of 4.30±2.0 cfu/g as compared to 4.02±1.0 cfu/g in feeds stored in roofed stores (Figure 4). This is attributed to exposure of feeds to unpredictable environmental conditions temperature ranging between 15.8 to 16.6°C and humidity ranging between 36.9 and 42.6% (Figures 2 and 3). The role of temperature and humidity in the survival of fungi was related to its influence on the cell membrane structure as well as on enzyme activities within the cell as indicated by earlier similar studies that had found that factors that contribute to mycotoxin contamination feed in Africa include environmental, socio-economic and many others (Wagacha and Muthomi, 2008).

This study revealed intensification types practiced by smallholder farmers were significantly influenced by the dairy system farmers' that were found in the rural dairy system was characterized by a majority 75% of the rural smallholder farmers practiced free range type of intensification (Table 2). This is credited to the low intensive farming system found in Olenguruone (rural system), an area of high agro-ecological potential for cropping and dairying. In addition, 23% of rural smallholder farmers practiced semi intensive which is attributed to the general characteristics of the farming system of integrating dairying with crop production and shifting from free grazing to semi-zero grazing in response to inter-generational partition of landholdings, keeping of lesser herds of dairy breeds, reliance on external feed resources and poor reproductive performance (Bebe, 2008).

In contrast, the peri-urban dairy system was characterized by a majority 93% of farmers practicing exclusively stall feeding and semi-zero grazing type of intensification (Table 2). This was attributed to the dairy farmers using their residential units as their space to practice dairying. Peri-urban areas have restricted space for dairying and due to small land holdings thus zero grazing and semi-zero grazing were opted (Gillah et al., 2012). An earlier study has shown higher incidences of hazardous mycotoxin residues in feeds and raw milk produced in intensive systems in Kenya (Kang'ethe and Lang'a, 2009).

The study revealed that the feeding practices were significantly associated at dairy systems and in each dairy system was significantly influenced by the type of intensification the farmer practiced. The 66% of farmers under the rural dairy system fed their dairy cattle with pasture and grass characteristic of the free range intensification as earlier shown in similar study (Msangi et al., 2005). Also, the 57% of in peri-urban dairy system farmers fed their cows on mixed crop residues, commercial dairy meal and Napier in the exclusive zero grazing and semi-zero grazing. This is because the dairy farmers in peri-urban areas had little or no access to grazing land and they relied mainly on purchased feeds and communal grazing lands such as pasture by the road side pavements (Gillah et al., 2012) (Table 2).

As a consequence of different types of intensification in each dairy system, which had varying practices on feeds, the levels of mycotoxins contamination in milk is expected to vary due different levels of exposure to the risk. The risk of contamination was found to be high in peri-urban system where most farmers practice stall feeding which was characterized by the animal feeding that are dry, concentrates and mostly purchased. On other hand, rural system had many farmers who have farms for free range and forages growing and as a result the risk of mycotoxins contamination was relatively lower.

During the wet season, napier, pasture and crop residues are the main source of feed in both dairy systems with 82% in rural and 64% in peri-urban dairy system respectively (Table 2). Napier grass was the main forage grown by over 70 % of smallholder farmers in both dairy systems especially to animals that were confined in stalls and fed mainly fed by cut-and-carry system (Orodho, 2005). This is credited to Napier grass being a high yielding forage producing dry matter yields that exceed most tropical grasses (Nyaata et al., 2002). While during the dry season, additional sources of feed that include silage and hay with 25% in rural dairy system and 59% in peri-urban dairy system were administered. A majority of farmers in both dairy systems used dried crop residues to feed animals during the dry season with 75% in rural dairy system and 41% in peri-urban dairy system. This is credited to seasonal quantitative, and qualitative feed shortages (Olaloku and Smith, 1998). This has a consequence risking the dairy cattle receiving sub-optimal level of nutrition especially during the dry periods (Msangi et al., 2005; Cole et al., 2008). In addition, high presence of fungi and mycotoxins in preserved forages such as silage, hay and straw have been reported (Lukuyu et al 2011; Skládanka et al., 2011). Hence, it can conclude that the risk of exposure to mycotoxins among dairy animals is higher during dry season than in wet season.

A higher percentage of peri-urban smallholder dairy farmers, 86% reported using dairy meal to concentrates for their dairy animals compared to 30% of rural small holder dairy farmers. This finding was similar to study of Kang'ethe and Lang'a (2009), which reported that majority 81% of urban smallholder dairy farmers used commercial feeds. The 96% of rural smallholder farmers who used commercial dairy meal was from farmers' cooperative society while 100% peri-urban smallholder dairy farmers purchased theirs from local retail agrovet shops (Table 2).

A majority of farmers in both dairy systems had never received training on proper feed storage from extension officers and this leads to farmers engaging in poor storage practices such as constructing poor storage facilities for feed conservation leading to feed contamination and feed losses (Lukuyu et al., 2011). Also many these farmers in both dairy systems had never received training of feed preservation about silage production. Silage is green forage preserved by lactic acid fermentation under anaerobic conditions. Lack of proper knowledge on silage production results to farmers who practice this producing low quality silage from poor fermentation that lead to excessive runoff, loss of nutrients and production of spoiled silage contaminated with mycotoxins producing fungi and their metabolites (Alonso et al., 2013; Cheli et al., 2013). Lack of awareness of source of mycotoxin contamination in animal, routine check of commercial feeds for fungal growth, knowledge on mycotoxicosis in dairy cows, knowledge about fungi in feeds and how to control them was, therefore, a risk for mycotoxins contamination.

The finding of storage facilities for feeds at the farmers' homes were in poor condition was similar to the study of Kang'ethe and Lang'a (2009), which revealed that storage facilities at Kenyan smallholder dairy farmers were not ideal for keeping feeds reporting that 6.5% of farmers kept feeds in raised stores, but under humid conditions, while 6.8% of farmers kept feeds on the floor under humid conditions. As presented in Table 6, poorly constructed storage feed or storage on open racks facilities lead to exposure of animal feed to favourable environmental conditions for fungal growth and mycotoxin production (Dagnas, and Membré, 2013).

In addition, studies have shown that interactions between these factors influence the dominance of fungi, particularly mycotoxigenic spp. (Magan et al., 2003). Often, fungi invade only a minor portion of a commodity where appropriate conditions for a growth such as sufficient water availability and aeration exist (Murphy et al., 2006).

Fungal growth and mycotoxin production are related to extreme weather conditions. Environmental conditions, especially high humidity and temperatures, favor fungal proliferation resulting in contamination of food and feed (Wagacha and Muthomi, 2008). The temperature of the surroundings affects fungal growth and influence mycotoxin production. The role of temperature in the survival of fungi may be related to its influence on the cell membrane structure as well as on enzyme activities within the cell as indicated by (Chin et al., 2010). Fungal grow over a temperature range of 10 to 40°C. Maximum fungal growth rates have obtained at 25°C and maximum mycotoxins produced at different temperatures with a range between 15 and 30°C (Oviedo et al., 2009). High relative humidity of 70 to 90% and warm temperatures 22 to 30°C enhance fungal growth and toxin production (Wu et al., 2011). The temperatures and humidity parameters observed were within the range that predisposed animal feed to the risk of fungal growth and mycotoxin production. The low mean feeds storage bag humidity of 37.40±0.0 % in rural system and 42.68±0.6% in peri-urban prevent growth of mycotoxigenic fungi when storing hay and dried crop residues (Wu et al., 2011). However the high mean humidity levels that were noted in silage silos of 72.00±0.6% favor fungal growth.

The optimal temperature range of 28 to 30°C is ideal for *Penicillium* spp .and 37 to 47°C for most *Aspergillus* (Pitt and Hocking, 1997). Conversely, *Fusarium* spp. can be regarded as psychrophilic, because capable of growth and reproduction in cold temperatures (Robert and Raymond, 1994). While that required for optimal production of most mycotoxins varies between 25 to 33°C depending on the fungus and the type of mycotoxins they produce (Pitt and Hocking, 1997). Trichothecenes could be produced by some members belonging to the *Fusarium* genera at lower temperatures as compared to most mycotoxins (Bhat et al., 2010). Optimal conditions for fungal growth do not coincide with those for mycotoxin production. However, the production of several different mycotoxins by the same species, or even the same strain, may not occur optimally under identical conditions.

Oxygen is an essential element required for fungal growth, but certain spp. can also grow under anaerobic conditions with the formation ethanol and organic acids (Wu et al., 2011). Most fungi require at least 1 to 2% O_2 for growth while mycotoxin production can also be influenced by the presence or absence of O_2 in the environment (Pitt and Hocking, 2009).

Biotic factors that can influence fungal growth and mycotoxins production are mainly living organisms that impact and influence the growth, composition, and structure of the fungi and mycotoxins (Magan and Aldred, 2007). Among these, insect pests are common invaders of crops and can causes problems in grains. They grow and multiply at water availabilities much drier than those at which fungal growth happens in grain. They can generate metabolic heat that generates water via metabolism of the organic material as metabolic water that can condense on grain surfaces due to temperature differentials and develop classic hot spots, which can quickly result in heating and induce fungal growth and grain spoilage (Magan et al., 2004).

Total fungal count is key for evaluation of hygiene quality of feeds and used for orientation in lower or higher probability of feeds containing mycotoxins (Alonso et al., 2013). The mean count of fungal growth in feeds was significantly different between the two dairy systems at ($P \leq 0.001$) with feeds from peri-urban had the higher fungi count of 4.22 ±0.4 cfu/g compared to 3.64±0.9 cfu/g feeds from rural (Figure 4). These fungal counts have exceeded levels proposed by European Union the as feed hygiene quality limits (1×10^4 cfu/g). These results show a high fungal activity that could affect palatability and reduced nutrient absorption determining a low hygienic quality and improper storage mycotoxins (Alonso et al., 2011; Krnjaja, 2011).

Conclusion

On-farm practices of handling of the feeds by the smallholder farmers predispose them to fungal growth and consequently mycotoxin contamination. Some of these predisposing practices include improper storage of the feeds among others. This study reveals that the risk of mycotoxin contamination was high in peri-urban dairy system than rural system because of several factors. First, peri-urban system is characterized by stall feeding of the dairy animals using dairy concentrates which have a higher risk for fungal growth than pastures used in the rural system. Secondly, these farmers have poor storage facilities for these concentrates and crop residues which offer predisposing conditions for fungal growth on feeds during storage. Lastly, most of these farmers have no knowledge on control of fungal growth in feeds. Therefore, we recommend that monitoring and evaluation of the commercial feeds by relevant authorities be done and also farmers especially in the peri-urban systems be sensitized about mycotoxins.

Conflict of Interests

The authors of this article declare that there is no conflict of interest whatsoever.

ACKNOWLEDGEMENT

This research work was supported financially by GlobE Project: RELOAD: Reduction of Post-Harvest Losses and Value Addition in East African Food Value Chains.

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