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Prevalence and contamination levels of aflatoxins in dairy cattle feeds from milk bulking groups in Malawi

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ABSTRACT
There is limited information about the natural occurrence of aflatoxins in dairy feedstuffs in Malawi. The aim of this study was to determine the natural prevalence rate of aflatoxins and quantify aflatoxin contamination levels in dairy cattle feeds collected from smallholder dairy cattle farms distributed across Dzaonewekha, Chitsanzo, Mpemba, Kavuzi and Lusangazi Milk Bulking Groups (MBGs) over three seasons in 2017. In total, 51 samples of feeds from 18 smallholder dairy farms were investigated. Immunoaffinity column chromatography coupled with solution fluorometry was used for quantification of aflatoxin with a detection limit of 1 µg /kg. Aflatoxin was detected in 88.2% of the samples with overall mean total aflatoxin contamination level of 30.57±5.44 ppb (19.36 ppb to 41.78 ppb, 95% confidence interval). Furthermore, 62.7% of the positive samples exceeded the EU limit of 5 ppb. Aflatoxin levels for Chitsanzo and Dzaonewekha MBGs differed significantly (P=0.0001) from those of Lusangazi, Kavuzi and Mpemba MBGs (5.21±12.85ppb and 5.45±14.37ppb vs. 63.38±11.36ppb, 39.57±10.67ppb and 30.08±11.73ppb, respectively for Mpemba, Lusangazi, and Kavuzi, MBGs). The study has reported a high aflatoxin prevalence rate in dairy cattle feeds and that levels of aflatoxin differed significantly by MBGs and season but not by feed type. No interaction was observed between feed type, season and MBG. There is therefore a great need for advocacy in enforcement of regulatory standards on aflatoxin control in Malawi to reduce aflatoxicosis hazards to both humans and livestock.

Key words: aflatoxicosis, aflatoxin levels, immunoaffinity column chromatography, Malawi, prevalence rate, solution fluorometry

RÉSUMÉ
Il existe peu d'informations sur la présence naturelle d'aflatoxines dans les produits laitiers au Malawi. Le but de cette étude était de déterminer le taux de prévalence naturelle des aflatoxines et de quantifier les niveaux de contamination par les aflatoxines des produits laitiers d'élevage collectés sur trois saisons en 2017dans de petites fermes laitières bovines répartis dans les groupements collectionneurs de lait (MBG) que sont Dzaonewekha, Chitsanzo, Mpemba, Kavuzi et Lusangazi. Au total, 51 échantillons d'aliments provenant de 18 petites exploitations laitières ont été examinés. La chromatographie d'immunoffinité en format colonne couplée à une fluorométrie en solution a été utilisée pour quantifier l'aflatoxine avec un seuil de détection de 1 µg/kg. L'aflatoxine a été détectée dans 88,2% des échantillons avec un niveau moyen de contamination par les aflatoxines de 30,57±5,44 ppb (19,36 ppb à 41,78ppb, Intervalle de confiance à 95% en partie par milliard). En outre, 62,7% des échantillons contaminés ont dépassé la limite de 5 ppb fixée par l'UE. Les niveaux

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d'aflatoxine des MBG Chitsanzo et Dzaonewekha étaient significativement différent (P=0,0001) de MBG Lusangazi, Kavuzi et Mpemba (5,21±12,85ppb et 5,45±14,37ppb vs 63,38±11,36ppb; 39,57±10,67ppb; et 30,08±11,73ppb, respectivement pour les MBG Mpemba, Lusangazi et Kavuzi). L'étude a révélé un taux élevé de prévalence d'aflatoxine dans les produits laitiers d'élevage et l'existence de différences significative dans les niveaux de contamination en aflatoxine selon le MBG et la saison, mais pas selon le type d'alimentation. Aucune interaction n'a été observée entre le type de produit, la saison et le MBG. Il est donc urgent de plaider en faveur de l'application des normes réglementaires relatives au contrôle de l'aflatoxine au Malawi afin de réduire les risques d'aflatoxicose pour l'homme et le bétail.

Mots-clés: aflatoxicose, taux d'aflatoxines, chromatographie d'immunoffinité en format colonne, Malawi, taux de prévalence, fluorométrie en solution

INTRODUCTION

Mycotoxin contamination is a major common global problem in livestock feeds. Aflatoxins are reported to be the second predominant mycotoxin in Africa (BIOMIN, 2016). Aflatoxins are secondary metabolites of the fungi species *Aspergillus flavus, A. parasiticus* and *A. nomius* belonging to the strongest natural occurring carcinogenic substances (Milita *et al.,* 2010). However, in Malawi there is limited information about the natural occurrence of aflatoxin in feedstuffs.

Aflatoxins are reported to cause around 90,000 cases of liver cancer each year and that they are strongly associated with stunting and immune suppression in children (Grace *et al.,* 2015). In cattle aflatoxin affects milk production, but of greater significance is that aflatoxins in feeds can be converted to toxic metabolites (AFM1) in milk, with even small amounts being readily detectable (Kang'ethe *et al.,* 2009). In all species, the evidence of aflatoxicosis is a general unthriftiness and reduction in weight gains, feed efficiency, immunity, and production. Since there is high likelihood of aflatoxins present in legumes and maize that form the bulk of animal feeds to find their way into commercially and locally manufactured feeds, dairy animals fed to such contaminated feeds would excrete milk that is contaminated with AFM1. This AFM1 will eventually contaminate raw and pasteurized milk since it is not heat labile. However, research data on prevalence rates and contamination levels of aflatoxins in dairy cattle feeds is very scanty in developing countries in Africa and parts of Asia. There is thus a big knowledge gap on the extent of aflatoxins contamination in the dairy value chain, yet the information is needed to ascertain the safety of these feeds and milk and milk products sold to the public. It is on this premise that the current research was undertaken with the aim to determine the natural prevalence and contamination levels of aflatoxins in samples of dairy cattle feeds and thereby ascertain the dairy feeds' safety status in Malawi.

MATERIALS AND METHODS

Study site selection. The study was carried out in five sites, i.e., Lusangazi Milk Bulking Group (MBG), Kavuzi MBG, Dzaonewekha, Chitsanzo MBGs and Mpemba MBG. These MBGs were spread across Mzimba, Nkhata Bay, Dedza, and Blantyre districts. The sites were randomly selected using multistage cluster sampling. The sites were drawn from three Milk shed areas of Malawi, i.e., Mzuzu Milk shed in the North, Central Milk shed in the Central region and the Shire highlands Milk shed area situated in the Southern region of Malawi. All together 18 smallholder dairy farms were sampled, three from each MBG. The farms picked from the MBG's roll were the top three milk producers where we were assured of finding dairy cattle feeds for supplementary feeding.

Sampling. Multistage cluster sampling was used, with Milk Shed Areas (MSAs), district, Milk Bulking groups (MBGs) and then dairy farmers randomly selected using computer-generated random numbers. To do this, sampling frames were constructed of Milk Shed Areas, District, Milk Bulking Groups within the selected districts. Two Milk Bulking Groups were selected from each sampling Milk Shed Area, and in each MBG, three eligible smallholder farms were randomly selected for periodic feed sampling. Sampling was planned to coincide with the rainy (December and April 2017), Cold dry (May and August 2017), Hot dry season (September and November, 2017) seasons of Malawi.

In order to get representative samples, bulk household dairy cattle feed (500 g) was scooped at three levels from a bag (top, middle and bottom) or at three positions in the feeding trough. One sample of each type of dairy feeds available was taken from the farmer. Dairy cattle feed samples were transported in cooler boxes and kept in a cold room at 4 ^{0}C. Analysis was carried out at the Chitedze Research Station Aflatoxin Laboratory which falls under the Directorate of Agricultural Research Services (DARS) and some at Valid Nutrition Laboratory in Kanengo.

Total Aflatoxin analysis in dairy cattle feeds. Quantification of aflatoxin in feeds was done using immunoaffinity column chromatography coupled with solution fluorometry. The detection limit of aflatoxins was 1 ppb with a range 0-50ppb.

Sample Extraction. Samples were thoroughly blended to be representative dairy feed. Twenty five (25) gram samples were ground with 5g NaCl and placed in the blender jar. To the jar, 125mL methanol : water (70:30) was added and blended at high speed for 2 minutes. The extract was poured into the fluted filter paper and the filtrate collected in a clean vessel. Fifteen millilitres of the filtered extract was pipetted into a clean vessel, diluted with 30 ml of purified water, mixed well and filtered through a 1.5μm glass microfiber filter into a clean vessel. These samples were subjected to affinity column chromatography using an AflaTEST column.

Determination of the prevalence rates of aflatoxins in dairy feed samples. The prevalence rate of aflatoxins in dairy cattle feeds samples was computed as a percentage of the number of positive samples divided by the total number of samples for each type of samples. The proportions of positives that exceeded the regional (Tanzanian = 10ppb) and international (European Union = 5ppb, FDA-USA = 20ppb, FAO = 10ppb) regulatory limits for aflatoxins were converted into percentages of the total positive samples.

Data analysis. The data were analyzed using descriptive and inferential statistics in Statistical Product Solutions and Services (SPSS) Version 22. Since data on total aflatoxin concentrations in dairy cattle feeds did not follow the normal distribution, it was log x+1 transformed for normality before any inferential statistics were done to avoid biasing the results. General Linear model was used for analysis of variance of aflatoxin levels among MBGs, feed types, and seasons and tukey test was used to separate means that were significantly different at 95% confidence level.

RESULTS

Prevalence of aflatoxin contamination in dairy cattle feeds in Malawi. Table 1 provides the prevalence rate of aflatoxin contamination of dairy cattle feeds in Malawi. The results of the current study show a high prevalence rate (88.2%) of aflatoxin contamination in smallholder dairy cattle feeds sampled across Malawi. There was higher prevalence rate of aflatoxin contamination in maize bran than the rest of the feedstuffs (94.7% vs. 84.2% and 84.6% for dairy mash and hay, respectively). The rainy season had the highest prevalence rate compared to the rest of the seasons (100% vs. 88.2% and 80% for the cold dry and hot dry seasons, respectively). Lusangazi and Mpemba Milk Bulking Groups (MBGs) had the highest rates compared to the rest of the MBGs while Chitsanzo had the least prevalence rate.

Cross-tabulations results (Tables 1) on prevalence of aflatoxins by feed type and season did not show any significant association while a significant association with Milk Bulking group (MBG) was observed.

Determination of dairy cattle feeds safety in Malawi based on 50ppb tolerable maximum limits for cattle. The results of the current study (Table 2 and Figs 1-3) revealed that only 17.6% of dairy cattle feeds were off safety margins (50ppb maximum tolerable limit for cattle) hence deemed unsafe for dairy cattle feeding in Malawi while the majority (82.4%) of the feeds fell within allowable safety margins.

Hot dry season (Fig 2 and Table 2) had the highest feed safety ratings (100%). This was followed by the rainy season (78.6 %). The cold dry season had the least rating (64.7%). The higher safety rate for the hot dry season could be due to lower humidity despite higher temperatures as compared with the rest of the seasons.

Dzaonewekha and Chitsanzo MBGs (Fig 3) recorded highest proportion of feed safety followed by Lusangazi and Mpemba while Kavuzi had the lowest (100% vs. 75% and 70% for Lusangazi, Mpemba and Kavuzi, respectively). However, cross-tabulations results (Tables 2) showed no significant associations between dairy cattle feed safety and feed type and Milk Bulking Group, respectively. However, feed safety and season (Table 2) were significantly associated. Dairy mash contributed the largest proportion of unsafe feeds followed by maize bran. Hay was the least contributor. In terms of agro-ecological zones (Fig 3), Kavuzi in Nkhata Bay district and Mpemba in Blantyre district were the major culprits in feedstuff's condemnation due to higher contamination levels.

Table 1. Aflatoxin prevalence rates cross-tabulations by season, feed type, and Milk Bulking Group

Variable	N	prevalence frequency	prevalence Valid %	Fischer's Exact test Value	P-Value
Season	51	45	88.2	2.935	0.217
Rainy	14	14	100		
Cold dry	17	15	88.2		
Hot dry	12	16	80		
Feed type	51	45	88.2	1.391	0.634
Maize bran	19	18	94.7		
Dairy mash	19	16	84.2		
Hay	13	11	84.6		
Milk bulking group	51	45	88.2	7.447	0.035
Lusangazi	12	12	100		
Kavuzi	10	8	80		
Dzaonewekha	9	8	88.9		
Chitsanzo	8	5	62.5		
Mpemba	12	12	100		

Table 2. Dairy cattle feeds safety cross-tabulations by feed type, Season and milk Bulking Group

Variable	N	Safety frequency	Safety Valid %	Fischer's Exact test Value	P-Value
Feed type	51	42	82.4	4.084	0.138
Maize bran	19	15	78.9		
Dairy mash	19	14	73.7		
Hay	13	13	100		
Season	51	42	82.4	8.676	0.007
Rainy	14	11	78.6		
Cold dry	17	11	64.7		
Hot dry	20	20	100		
Milk bulking group	51	42	82.4	5.269	0.229
Lusangazi	12	9	75		
Kavuzi	10	7	70		
Dzaonewekha	9	9	100		
Chitsanzo	8	8	100		
Mpemba	12	9	75		

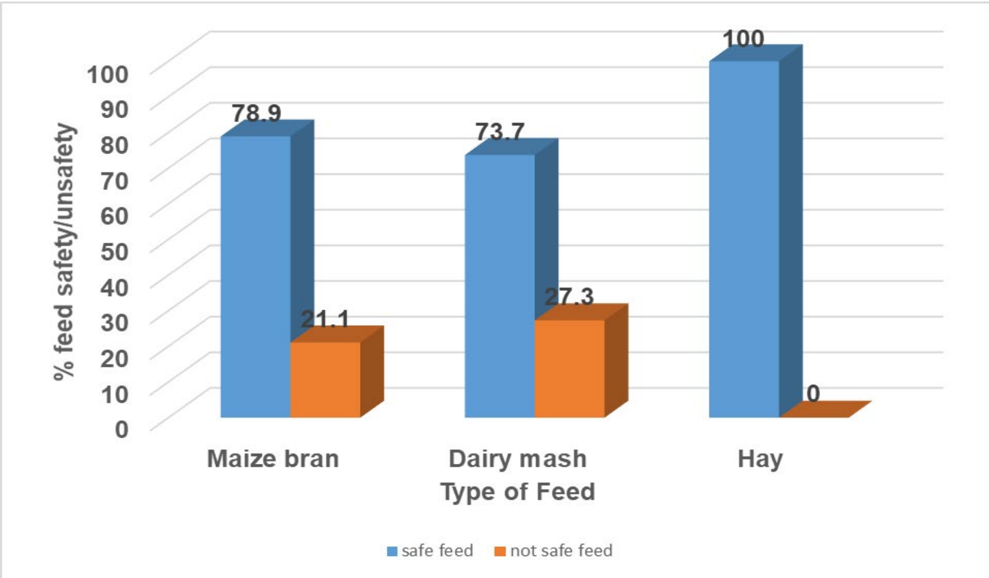

Figure 1: Dairy cattle feed safety by feed (stuffs) type

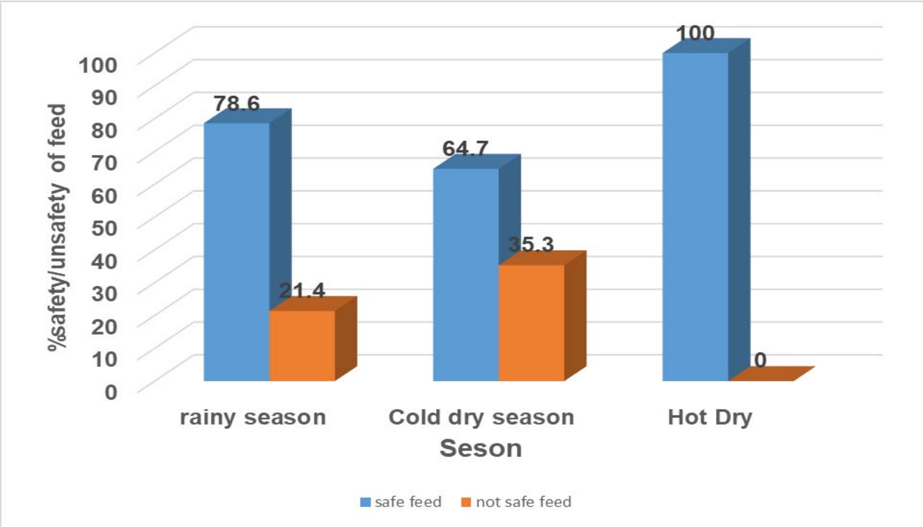

Figure 2. Dairy cattle feed safety status by season of the year

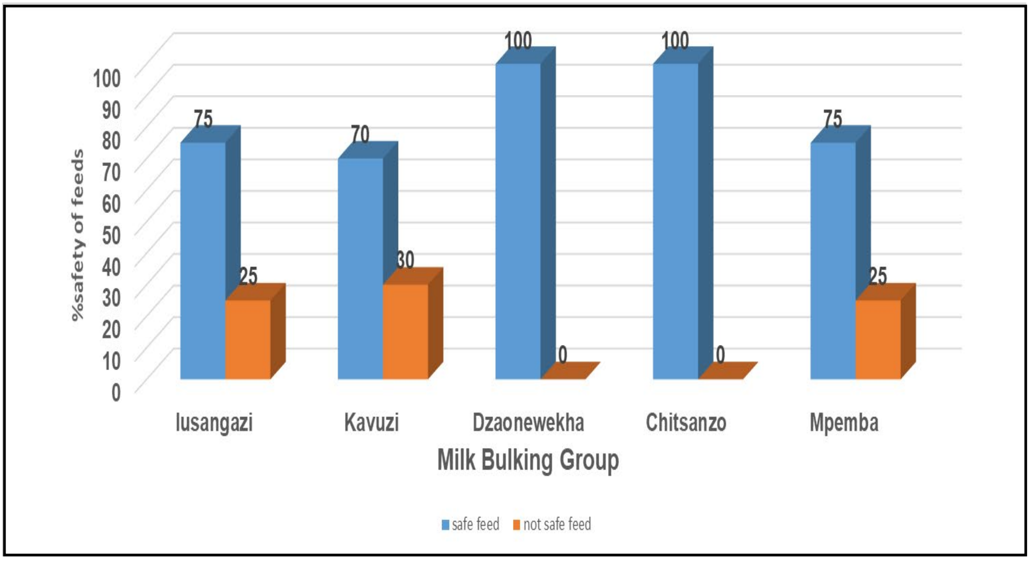

Figure 3. Dairy cattle feed safety status by Milk Bulking Group

Aflatoxin contamination levels of Dairy cattle feeds in Malawi. Table 3 presents aflatoxin contamination levels in parts per billion by feed type, season and milk bulking groups. There were no significant differences (P=0.968) in aflatoxin contamination levels between feed types. However, there was numerically high (40.56±9.58ppb vs. 30.13±8.74ppb and 18.36±10.06ppb for dairy mash and Hay, respectively) aflatoxin contamination in maize bran seconded by dairy mash while hay had least contamination levels.

Table 3. Aflatoxin contamination levels of Dairy cattle feeds in parts per billion (ppb) by feed type, Milk Bulking Group and season

Variable	N	Mean	SE	Min	Max	P - value
Feed type	51					
Maize bran	19	40.56	9.58	20.83	60.29	
Dairy mash	19	30.13	8.74	12.13	48.13	0.968
Hay	13	18.36	10.06	-2.36	39.07	
Milk Bulking group	51					
Lusangazi	12	39.57a	10.67	17.60	61.54	
Kavuzi	10	30.08ab	11.73	11.92	60.25	0.0001
Dzaonewekha	9	5.21c	12.85	-21.26	31.68	
Chitsanzo	8	5.45c	14.37	-24.14	35.04	
Mpemba	12	63.38ad	11.36	39.98	86.77	
Season	51					
Rainy	14	34.96a	10.16	14.03	55.89	
Cold dry	17	52.98ab	9.03	34.38	71.58	0.0001
Hot dry	20	4.26c	9.17	- 14.63	23.15	

[abc]Means with different superscripts are significantly different at p = 0.05.

Table 4. Frequency table showing positive Dairy cattle feed samples that exceeded the FAO/EU / FDA Standards

Variable	>5ppb			>10ppb			>20ppb			>50ppb		
	N	Fr	%	N	FR	%	N	Fr	%	N	Fr	%
Type of feed	51	32	62.7	51	29	56.9	51	19	37.3	51	9	17.6
Maize bran	19	13	25.5	19	11	21.6	19	7	13.7	19	4	7.8
Dairy mash	19	10	19.6	19	9	17.6	19	7	13.7	19	5	9.8
Hay	13	9	17.6	13	9	17.6	13	5	9.8	13	0	0.0
Season	51	32	62.7	51	29	56.9	51	19	37.3	51	9	17.6
Rainy	14	10	19.6	14	8	15.7	14	6	11.8	14	3	5.9
Cold dry	17	6	19.4	17	6	19.4	17	5	16.1	17	3	9.7
Hot dry	20	5	16.1	20	3	9.7	20	1	3.2	20	0	0.0
Milk Bulking Group	51	32	62.7	51	29	56.9	51	19	37.3	51	9	17.6
Lusangazi	12	9	17.6	12	8	15.7	12	6	11.8	12	3	17.6
Kavuzi	10	6	11.8	10	6	11.8	10	5	9.8	10	3	5.9
Dzaonewekha	9	4	7.8	9	2	3.9	9	1	2.0	9	0	0.0
Chitsanzo	8	1	2.0	8	1	2.0	8	0	0.0	8	0	0.0
Mpemba	12	12	23.5	12	12	23.5	12	7	13.7	12	3	5.9

Table 5. Means in parts per billion for the interaction effect of feed type by Milk Bulking Group (MBG)

Feed type	MBG	Mean	Std error	95% confidence interval		P - value
				Min	Max	
Maize bran	Lusangazi	43.00	21.55	-1.39	87.39	**0.670**
	Kavuzi	76.00	35.20	3.51	148.49	
	Dzaonewekha	3.30	21.55	-41.09	47.69	
	Chitsanzo	1.23	20.32	-40.62	43.09	
	Mpemba	97.00	14.37	67.41	126.59	
Dairy mash	Lusangazi	68.00	21.55	23.61	112.39	
	Kavuzi	41.00	17.60	4.76	77.25	
	Dzaonewekha	6.48	15.89	-26.24	39.19	
	Chitsanzo	9.67	20.32	-32.19	51.52	
	Mpemba	44.50	24.89	-6.76	95.76	
Hay	Lusangazi	18.33	14.37	-11.26	47.93	
	Kavuzi	19.50	16.59	-14.67	53.67	
	Dzaonewekha	-	-	-	-	
	Chitsanzo	-	-	-	-	
	Mpemba	15.00	24.89	-36.26	66.26	

[abc] Means with different superscripts are significantly different at p = 0.05.

Table 6. Means in parts per billion for the interaction effect of feed type by season

Feed type	Season	Mean	Std error	95% confidence interval		P - value
				Min	Max	
Maize bran	Rainy	41.02	13.44	13.33	68.70	**0.191**
	Cold Dry	85.50	21.55	41.11	129.89	
	Hot Dry	10.00	17.27	-25.57	45.57	
Dairy mash	Rainy	25.30	21.55	-19.09	69.69	
	Cold Dry	61.08	13.44	33.40	88.77	
	Hot Dry	1.58	13.44	-26.10	29.27	
Hay	Rainy	32.50	21.55	-11.89	76.89	
	Cold Dry	20.50	14.37	-09.097	50.09	
	Hot Dry	1.00	17.60	-35.25	37.25	

[abc] Means with different superscripts are significantly different at p = 0.05.

Table 7. Shows means in parts per billion for the interaction effect of season by Milk Bulking Group (MBG)

Season	MBG	Mean	Std error	95% confidence interval		P - value
				Min	Max	
Rainy	Lusangazi	53.00	17.60	16.76	89.25	**0.122**
	Kavuzi	58.00	24.89	6.74	109.26	
	Dzaonewekha	5.35	21.55	-39.04	49.74	
	Chitsanzo	2.47	20.32	-39.39	44.32	
	Mpemba	44.50	24.89	-6.76	95.76	
Cold dry	Lusangazi	81.00	17.60	44.76	117.25	
	Kavuzi	48.75	17.60	12.51	85.00	
	Dzaonewekha	12.33	20.32	-29.52	54.19	
	Chitsanzo	9.50	24.89	-41.76	60.76	
	Mpemba	93.00	17.60	56.76	129.25	
Hot dry	Lusangazi	3.00	18.55	-32.21	41.21	
	Kavuzi	1.50	17.60	-34.75	37.75	
	Dzaonewekha	1.50	21.55	-42.89	45.89	
	Chitsanzo	0.33	20.32	-41.52	42.19	
	Mpemba	23.00	14.37	-6.59	52.59	

Of all the positive samples (Table 4), 62.7%,56.9%, 37.3% and 17.6% exceeded the European Union, Tanzanian Food and Drug Agency (TFDA)/ Food and Agriculture Organization (FAO), Food and Drug Agency of United States of American (FDA-USA) standards of 5ppb, 10ppb, 20ppb, safety maximum limit for dairy cattle (50ppb), respectively. No significant interaction ($P > 0.05$) was observed between feed type, season and Milk Bulking Group (Table 5, 6, 7).

Aflatoxin contamination levels of dairy cattle feeds by Milk Bulking Group (MBG) as presented in Table 3 clearly demonstrate significantly lower ($P=0.0001$) aflatoxin contamination levels of dairy cattle feeds for Dzaonewekha and Chitsanzo MBGs from the Central Milk Shed area compared to the rest of MBGs from Shire Highlands and Mzuzu Milk shed areas (5.21±12.85ppb and 5.45±14.37ppb vs. 63.38±11.36ppb, 39.57±10.67ppb and 30.08±11.73ppb for Mpemba, Lusangazi and Kavuzi MBGs, respectively). However, contamination levels for Mpemba, Lusangazi and Kavuzi did not differ significantly. The same was observed for aflatoxin contamination levels of Dzaonewekha and Chitsanzo MBGs. significant differences ($P = 0.0001$) were also observed between seasons with the cold dry season recording the highest level of aflatoxin contamination (52.98±9.03 vs. 34.96±10.16, 4.26±9.17, for Rainy and Hot dry season, respectively) followed by rainy season and hot dry season in that order.

DISCUSSION

Prevalence and aflatoxin contamination levels of dairy cattle feeds in Malawi. The 88.2% prevalence rate of aflatoxin contamination in the smallholder dairy cattle feeds sampled across Malawi is higher than that reported by Kajuna *et.al.* (2013), Nyangi *et. al.* (2016) and Sahin *et. al.* (2016) in Tanzania. These authors reported aflatoxin prevalence rates of 26.3%, 32% and 60% in dairy feeds, maize samples and animal feeds, respectively. The high prevalence rate in this study further disagrees with BIOMIN (2016) that reported a lower prevalence rate for aflatoxins in livestock feeds in Africa of 70%. The prevalence rate in the current study however, corroborates with Gizaschew *et. al.* (2016) who reported high aflatoxin contamination in dairy feeds in Ethiopia and also Rodriques *et al.* (2011) whose aflatoxin contamination prevalence rates ranged from 0 to 94% for Middle East and the rest of Africa and Kang'ethe and Langa (2009) who reported prevalence rates for dairy meal and mixed dairy meal of 98.6% and 85%, respectively, in Kenya. The higher prevalence rate found in the current study could indicate poor handling of dairy feedstuffs by dairy farmers. This has an implication of exposing dairy cows to aflatoxicosis hazards that have the capacity to compromise both human health and dairy herd health and productivity in Malawi. As a result of such a high prevalence rate farmers would make losses if lactating cows are not attaining their optimum productivity during the lactation period.

The revelation from the current study that 62.7%, 56.9%, 37.3% and 17.6% (Table 4) of the positive samples had their total aflatoxin contamination levels exceeding the European Union (EU), Tanzanian Food and Drug Agency (TFDA) / Food and Agriculture Organization (FAO) of United Nations, Food and Drug Agency-United States of America (FDA-USA) and other international standards was consistent with Senerwa *et al.* (2016). They reported that for dairy feeds collected from farmers in Kenya, between 33.3-85% of the positive feeds exceeded the Tanzanian/FAO limit of 10ppb. However, the findings of the current study contradict with Kearie *et al.* (2016) who reported between 11%-16% of the contaminated maize and sorghum exceeded the TFDA /FAO limits of 10ppb. The proportion of dairy feed samples exceeding the international and regional standards reported in the current study far beats those reported elsewhere by Nyangi *et. al.* (2016) and Sahin *et. al.* (2016). This current study finding has serious trade implications as most of these feeds would not be allowed for export to international markets. Besides, milk produced by animals that feed on contaminated feeds would very likely have aflatoxin contaminations above the 0.05ppb AFM1 threshold. Fink-Gremmels (2008) alluded to the fact that approximately 2% of the Aflatoxin B1 (AFB1) that the dairy animal consumes from feeds is transferred to the milk as the aflatoxin M1 metabolite. This carry-over AFM1 poses a serious public health hazard to the general public consuming milk produced under those conditions.

Despite the higher prevalence rate (88.2%) of aflatoxin contamination in Malawi, 82.4% of the dairy cattle feeds were deemed safe for cattle feeding based on Maximum Tolerable Limit of 50ppb for cattle. However, this finding should not in any way encourage dairy farmers in Malawi to feed cattle on contaminated feeds. Dairy cattle can still efficiently excrete aflatoxin M1 (a metabolite of AFB1) (Fink-Gremmels, 2008) in milk despite this lower risk reported here.

The significantly higher aflatoxin levels reported for Mpemba MBG (Table 43) as compared to the rest of the MBGs could be due to climatic and feed handling procedures followed by dairy farmers. This also corraborates well with our earlier baseline findings of lower awareness levels on aflatoxin contamination in Mzuzu (which covers Lusangazi) and Shire Highlands (where Mpemba is located) milk shed areas as compared to the Central milk shed area (where Chitsanzo and Dzaonewekha are located) that had slightly higher awareness on aflatoxin contamination. The prolonged rain creates humid conditions in Shire Highlands and parts of Mzuzu that could also have favoured the development of aflatoxigenic Aspergillus fungi that produce aflatoxins under such conditions. Sufficiently high moisture content and temperature are the two favourable conditions for aflatoxigenic fungi growth.

CONCLUSIONS

From the current study, it can be concluded that high aflatoxin prevalence rate and contamination levels have been confirmed in dairy mash, maize bran and hay dairy feeds in Malawi. A large proportion of the aflatoxin contamination levels exceeded the regional, Food and Drug Agency-United States of America (FDA-USA), Food and Agriculture Organization (FAO), European Union (EU) standards. However, despite this large proportion of the aflatoxin contamination levels, a higher percent of dairy cattle feeds were still deemed safe for dairy cattle feeding based on 50ppb maximum tolerable limits for cattle. The current study findings have serious trade implications as most of these feeds would not be allowed for export to international markets. Besides, milk produced by animals that feed on contaminated feeds would very likely have aflatoxin contaminations going above the 0.05ppb AFM1 threshold.

There were both seasonal and agro-ecological variations in Aflatoxin contamination of dairy feeds in Malawi. Cold dry season and rainy season had the highest contamination levels while Hot dry season had the lowest. The MBG that was hard hit by aflatoxin contamination was Mpemba in Blantyre district followed by Lusangazi in Mzimba distict and Kavuzi in Nkhata-Bay with Dzaonewekha and Chitsanzo MBGs in Dedza district reporting lowest figures. No interaction effect was observed between MBG, season and feed type. Owing to the foregoing, there is therefore a great need for advocacy in enforcement of regulatory standards on aflatoxin control in Malawi to reduce aflatoxicosis hazards to both humans and livestock.

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STATEMENT OF NO-CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

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