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The influence of mycotoxins on quality indicators of milk in cows in a large livestock complex

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Abstract. The research was carried out in the dairy complexes of Lednevo breeding farm in the Yuryev-Polsky district, the Vladimirov region. The purpose of the study was to scientifically substantiate the influence of mycotoxins on quality indicators of milk in cows in a large livestock complex. At each of the complexes, 20 cows were selected. The milk samples were taken to determine the content of protein, fat, casein, albumin, globulins, lactose, total solids, dry skimmed milk residue using automatic milk composition analyzer (Combi Milkoscan, FossElectric, Denmark). Analysis of mycotoxin residues in milk was carried out using liquid chromatography mass spectrum. To determine hematological parameters and perform biochemical tests, BioSystemsA25 automatic analyzer (USA) was used. The results of automatic Foss analyzer showed a decrease in dry matter content in milk from cows that received feed with a higher concentration of mycotoxins (10.44 ± 0.22 versus 14.71 ± 0.45 %). Thus, mycotoxins in high concentrations affect amino acid metabolism. Threonine, an essential amino acid obtained from aspartate in bacteria and plants, is metabolized to form glycine and serine, which have a great influence on metabolic processes. Thus, feeding lactating cows with fodder containing mycotoxins reduced feed consumption, milk yield, and also had negative effect on hematological and biochemical blood parameters of experimental cows.

Keywords: biochemical test, dry matter, lactation period, amino acid composition, liquid chromatography mass spectrum, hematological parameters, biochemical parameters

Conflict of interests. The authors declare that they have no conflict of interests.

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Introduction

Intensification of livestock industry, aimed at obtaining maximum profit from dairy cows, is possible only if feeding standards are observed, considering animal productivity [1, 2]. Minor violations in technology of feed preparation can lead to contamination by fungi with subsequent formation of mycotoxins [3].

Mycotoxins, if consumed in large quantities, cause adverse biological effects. Symptoms of chronic mycotoxin damage include depression, changes in appetite, fever, sporadic diarrhea and weight loss [4]. Acute mycotoxicosis in severe form can be fatal but is usually characterized by decreased feed intake and decreased milk production [5, 6]. Acute symptoms have been observed in cows exposed to aflatoxin at concentrations above 100 mg/kg [7].

Mycotoxins, which are a diverse group of chemicals, cause various toxic reactions [8]. Thus, mycotoxicosis can be determined not by specific symptoms, but by the consequences: decreased feeding efficiency, immunosuppression, impaired liver and kidney function, decreased reproductive ability [9, 10].

Aflatoxins, zearalenones and deoxynivalenol are the three main mycotoxins found in bovine milk. Moreover, aflatoxin M1 is the only mycotoxin for which the maximum residual content in milk is established in all countries of the world [11, 12]. Mycotoxins found in milk come from fungal-contaminated feed fed to lactating cows. In turn, feed for dairy cattle is often susceptible to contamination with mycotoxins during harvesting, processing and storage [13, 14].

Mycotoxin contamination typically occurs in temperate regions and is often found in feedstuffs such as wheat, barley, oats, and corn [15, 16]. Therefore, contamination of feed for dairy cows with fungi and presence of mycotoxins is almost inevitable.

The purpose of the research was to study the effect of mycotoxins in feed of lactating cows on hematological and biochemical blood parameters, milk productivity and quality.

Materials and methods

The studies were carried out in dairy complexes of Lednevo breeding farm, Yuryev-Polsky district, Vladimirov region.

After assessing feed for mycotoxins using high-pressure liquid chromatography on mass spectrophotometer, it was revealed that at complex No. 1, contamination of feed with fungi was higher than at complex No. 2 (Table 1).

Table 1

Mycotoxin content in feeds of Lednevo breeding farm

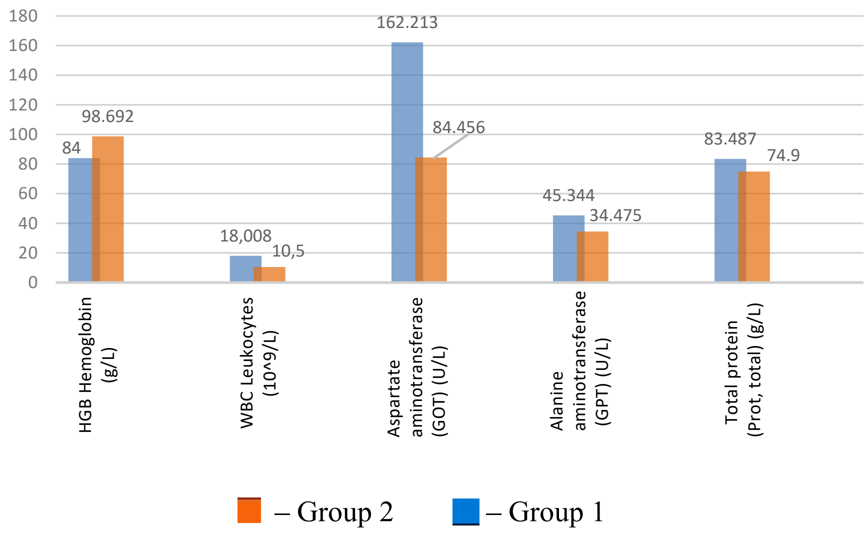
Lednevo	Fodder	Mycotoxin		
		Deoxynivalenol DON, mg/kg	Zearalenone ZEN, mg/kg	Aflatoxin M1, mg/kg
Complex No. 1	Silage	4.615 ± 0.088	246.428 ± 0.044	49.004 ± 2.116
	Concentrates	4.141 ± 0.075	526.141 ± 14.138	54.912 ± 1.431
Complex No. 2	Silage	2.0411 ± 0.072	155.097 ± 0.092	21.033 ± 2.234
	Concentrates	2.152 ± 0.104	222.102 ± 9.431	28.731 ± 1.642

At each of the complexes, 20 cows were selected. Content of protein, fat, casein, albumins, globulins, lactose, total dry matter and dry skimmed milk residue was determined using automatic milk composition analyzer (Combi Milkoscan, FossElectric, Denmark). Analysis of mycotoxin residues in milk was carried out using liquid chromatography mass spectrum.

To determine hematological parameters and conduct biochemical tests, BioSystemsA25 automatic analyzer (USA) was used.

Results and discussion

The results of hematological and biochemical studies of blood of experimental cows showed that high content of mycotoxins in feed resulted in decrease in hemoglobin (84.000 ± 3.109 versus 98.692 ± 7.620 g/L) and increase in content of leukocytes (18.008 ± 4.499 versus 10.500 ± 2.250 109/L), aspartate aminotransferase (162.213 ± 43.080 vs. 84.456 ± 15.884 U/L), alanine aminotransferase (45.344 ± 3.835 vs. 34.475 ± 5.446 U/L) and total protein (83.487 ± 4.694 vs. 74.900 ± 3. 556 g/L) (Fig.).



Hematological and biochemical parameters of blood serum of experimental cows

Source: created by the authors

In cows that received feed more contaminated with zearalenone and aflatoxins, activity of liver enzymes increased. Thus, these mycotoxins have hepatotoxicity, hematotoxicity and genotoxicity.

Total protein levels were higher in the group consuming feed with higher levels of zearalenone and aflatoxin. This may be due to inhibition of protein synthesis at cellular level and, therefore, primarily damage rapidly proliferating immune cells. Moreover, aflatoxin inhibits protein synthesis and cell proliferation and may have a selective effect on different subpopulations of lymphocytes and leukocytes.

Analysis of milk of experimental cows revealed that concentration of mycotoxins in feed affected the residual amounts of aflatoxins, zearalenone and deoxynivalenol. Hence, after consuming concentrates with an average DON of 2.152 ± 0.104 mg/kg, mycotoxin content in milk was found to be 0.508 ± 0.116 mg/kg (2nd group of experimental cows), while in milk of experimental cows of 1st group, this indicator was 1.022 ± 0.014 mg/kg, with its presence in feed within the range of 4.615 ± 0.088 mg/kg. A similar picture was observed for the indicators of aflatoxin and zearalenone (Table 2).

Table 2

Mycotoxins in bovine milk

Mycotoxins	Units	Experimental cows	
		1 group	2 group
Deoxynivalenol (DON)	mg/kg	1.022 ± 0.014	0.508 ± 0.116
Zearalenone (ZEN)	mg/kg	1.503 ± 0.146	0.971 ± 0.081
Aflatoxin M1	mg/kg	1.519 ± 0.285	0.622 ± 0.325

When determining the effect of various concentrations of mycotoxins on milk productivity of cows and composition of milk, the following indicators were recorded: yield of dry matter, milk fat, milk protein, lactose, total protein, casein, albumin and globulin (Table 3).

Table 3

Milk productivity and milk composition

Indicators	Unit	Experimental cows	
		1 group	2 group
		±	±
Milk yield for 305 days of lactation	kg	8528.94 ± 111.54	9153.81 ± 99.72*
Dry matter yield	kg	743.48 ± 14.63	998.53 ± 18.54*
Milk fat yield	kg	378.08 ± 9.21	485.54 ± 7.73*
Milk protein yield	kg	316.08 ± 7.45	399.71 ± 5.49*
Lactose yield	kg	434.32 ± 6.78	481.6 ± 11.12*
Dry matter content in milk	%	10.44 ± 0.22	14.71 ± 0.45*

End of the table 3

Indicators	Unit	Experimental cows	
		1 group	2 group
		±	±
Dry matter incl. dry skimmed milk residue	%	7.34 ± 0.35	8.54 ± 0.22
Fat	%	3.41 ± 0.17	3.49 ± 0.12
Total protein	%	3.17 ± 0.15	3.18 ± 0.24
Casein	%	2.74 ± 0.26	2.77 ± 0.09
Albumins	%	0.68 ± 0.16	0.69 ± 0.11
Globulins	%	0.47 ± 0.09	0.59 ± 0.04
Lactose	%	4.79 ± 0.64	4.84 ± 0.56

* — P ≤ 0.05, ** — P ≤ 0.01, *** — P ≤ 0.001.

In a retrospective analysis using Selex program, it was found that cows of the 1st experimental group had a significantly higher milk yield during 305 days of lactation ($P \leq 0.05$) than cows of the 2nd experimental group (9153.81 ± 99.72 versus 8528.94 ± 111. 54 kg).

The results of automatic Foss analyzer showed decrease in dry matter content in milk from cows that received feed with a higher concentration of mycotoxins (10.44 ± 0.22 versus 14.71 ± 0.45 %). At the same time, the percentage of dry skimmed milk residue, fat, total protein, casein, albumins, globulins and lactose in dry matter changed slightly.

Cows received feeds containing moldy concentrates experienced significant changes in production parameters, including feed intake, milk composition and dry matter yield, which consists of milk fat, milk protein, milk sugar and minerals.

At low concentrations, zearalenone and aflatoxins suppress lactogenesis, while at high concentrations they can exhibit xenobiotic activity, thereby affecting enzymes involved in bioconversion. Moreover, high levels of mycotoxins in feed can cause organ damage or immune suppression in cows.

To determine biological value of milk obtained from experimental cows, a quantitative method for content of non-essential and essential amino acids was used. In raw milk samples, we identified 11 nonessential and 4 essential amino acids (Table 4).

Table 4

Content of non-essential and essential amino acids in milk

Indicator	Unit	Experimental cows	
		1 group	2 group
		±	±
Non-essential amino acids			
Tryptophan	mg/100 g	48.97 ± 0.07	50.27 ± 0.10
Arginine	mg/100 g	120.04 ± 0.03	121.74 ± 0.08
Valin	mg/100 g	188.74 ± 0.11	190.31 ± 10.05

End of the table 4

Indicator	Unit	Experimental cows	
		1 group	2 group
		±	±
Methionine	mg/100 g	85.74 ± 4.12	87.01 ± 3.06
Leucine	mg/100 g	322.15 ± 10.04	323.98 ± 11.01
Isoleucine	mg/100 g	187.15 ± 10.09	188.76 ± 7.07
Phenylalanine	mg/100 g	168.85 ± 7.12	171.24 ± 10.15
Cystine	mg/100 g	25.48 ± 0.12	27.85 ± 0.08
Lysine	mg/100 g	258.94 ± 3.07	260.71 ± 2.93
Histidine	mg/100 g	88.06 ± 1.09	90.11 ± 1.12
Threonine	mg/100 g	148.16 ± 4.07	150.42 ± 3.17
Essential amino acids			
Tyrosine	mg/100 g	181.82 ± 9.12	183.18 ± 7.04
Glutamic acid	mg/100 g	714.28 ± 6.27	716.17 ± 5.18
Glycine	mg/100 g	45.38 ± 1.08	47.02 ± 1.12
Aspartic acid	mg/100 g	215.92 ± 9.18	217.06 ± 5.01

Tests for biological value of milk revealed changes in content of essential and non-essential amino acids in milk of experimental cows. Thus, quantitative indicators of tryptophan in milk of cows received feed with higher content of mycotoxins were 48.97 ± 0.07 versus 50.27 ± 0.10 mg/100 g in milk of cows from the 2nd experimental group. A similar picture was observed in content of arginine, valine, methionine, leucine, isoleucine, phenylalanine, cystine, lysine, and histidine.

Hence, mycotoxins in high concentrations affect amino acid metabolism. Thus, threonine, an essential amino acid obtained from aspartate in bacteria and plants, is metabolized to form glycine and serine, which have a great influence on metabolic process.

The research showed that exposure to mycotoxins derived from feed can lead to disruption of amino acid metabolism. Glycine, serine and threonine are amino acids that produce glucose. Glucose, in turn, is an important metabolic factor, and changes in glucose metabolism due to exposure to mycotoxins can affect amino acid metabolism in mammary gland.

Conclusion

Therefore, feeding lactating cows with fodder containing mycotoxins reduced feed consumption, milk yield, and also had negative effect on hematological and biochemical blood parameters of experimental cows.

In cows that received feed more contaminated with zearalenone and aflatoxins, the activity of liver enzymes increased. These mycotoxins have hepatotoxicity, hematotoxicity and genotoxicity.

Feeding cows with fodder containing moldy concentrates significantly affected composition of milk and yield of dry matter, which is based on milk fat, milk protein, milk sugar and minerals.

In addition, content of metabolites in milk of experimental cows changed. The impact of high concentrations of mycotoxins on amino acid composition leads to changes in the metabolic processes, disruption of amino acid metabolism in mammary glands.

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Влияние микотоксинов на качественные показатели молока у коров в условиях крупного животноводческого комплекса

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Аннотация. Исследования проводили в молочных комплексах племенного хозяйства ОАО "Леднево" Юрьев-Польского района Владимировской области с целью научного обоснования влияния микотоксинов на качественные показатели молока у коров в условиях крупного животноводческого комплекса. На каждом из комплексов подобрали по 20 коров, у которых брали пробы молока на определение содержания белка, жира, казеина, альбуминов, глобулинов, лактозы, общего количества сухих веществ, сухого обезжиренного молочного остатка с использованием автоматического анализатора состава молока (Combi Milkoscan, FossElectric, Дания). Анализ остатков микотоксинов в молоке проводили с помощью масс-спектр жидкостной хроматографии. Для определения гематологических показателей и проведения биохимических тестов использовали автоматический анализатор BioSystemsA25 (США). Результаты исследования на автоматическом анализаторе Foss показали понижение содержания сухого вещества в молоке от коров, которые получали корма с более высокой концентрацией микотоксинов (10,44 ± 0,22 против 14,71 ± 0,45 %). Следовательно, микотоксины в больших концентрациях влияют на метаболизм аминокислот. Так, треонин — незаменимая аминокислота, получаемая из аспартата бактерий и растений, метаболизируется с образованием глицина и серина, которые имеют большое влияние на метаболический процесс. В период скармливания лактирующим коровам корма, содержащие микотоксины, снижало потребление корма, надои молока, а также оказывало негативное влияние на гематологические и биохимические показатели крови экспериментальных коров.

Ключевые слова: биохимический тест, сухое вещество, период лактации, аминокислотный состав, масс-спектр жидкостной хроматографии, гематологические показатели, биохимические показатели

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