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DOES THE MYCOTOXIN INGESTION BY BEEF HEIFERS ON FEEDLOT CHANGE THE PRODUCTIVE PARAMETERS?

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Abstract
In intensive beef cattle production systems, silage, corn, soy bean, and their coproducts are commonly used as feed. However, these ingredients are highly susceptible to contamination by fungi and mycotoxins, which may lead to immunological challenges and reduce animal production. The aim of the present study was to evaluate the effects of mycotoxin contamination of diet on intake, digestibility, and performance of heifers. Twenty non-pregnant (Nellore) heifers (age, >18 months; initial body weight, 348±30 kg) were used and randomly distributed in two treatments: (1) control (non-contaminated diet) and (2) zearalenone-contaminated diet (300 ppb). The diet comprised 70% corn silage and 30% concentrate. Individual dry matter intake and digestibility were estimated using external and internal markers. Heifer body weight was evaluated every week without fasting to calculate performance. The experimental design was completely randomized. Each animal was considered one experimental unit. Assumptions were tested for variance analyses (error normality, independence of errors, and homogeneity of variances) ($p<0.05$). There were no differences in dry matter intake ($p=0.96$) and digestibility ($p=0.62$). Performance (kg/day) did not vary as a function of zearalenone ingestion ($p=0.68$). Therefore, contamination of diet with 300 ppb zearalenone did not affect the intake, digestibility, and performance of feedlot-finished heifers.

Keywords: Animal Nutrition. Beef Cattle. *Bos indicus.* Contaminated Feed. Zearalenone.

1. Introduction

In most of the Brazilian territory, decreases in forage production and nutritional value in the dry season (autumn and winter) represent a great challenge to beef cattle production. Strategies must be adopted to obtain productivity efficiency compatible with the body conditions for breeding or slaughter heifers depending on the objective of the production system (McFarlane et al. 2017). In this context, intensification of livestock production demands the use of silage (Araújo et al. 2020) or grains (Barbero et al., 2020) to promote weight gain. However, animals receiving such feed are at an increased risk of infection by fungi and mycotoxins (Custódio et al. 2019). Feed contamination may lead to economic losses to the beef cattle industry by reducing animal performance or even causing death in severe cases (Custódio et al. 2019).

Zearalenone (ZEA) is a lactone produced by fungi of the genus *Fusarium*, which are very common in feed for farm animals (Hagler and Winston 2001). Their growth is strongly affected by environmental factors, such as temperature and humidity (Neme and Mohammed 2017). Ingesting mycotoxins through fungal-contaminated food can lead to health problems in humans and non-human animals. Mycotoxicosis produces acute or chronic effects, depending on the contaminating species and degree and intoxication; however, the degree of contamination (or the concentration of mycotoxins) that can produce detrimental effects remains unknown (Aslam et al. 2016). The negative effects of ZEA on farm animals, particularly those related to the non-ruminant animals, have been reported (Zain 2010). Health challenges can alter the metabolism, compromise the intake, digestibility and, ultimately, performance. In the present study, we hypothesized that the intake of diet contaminated with 300 ppb ZEA by feedlot-finished heifers would alter their intake, digestibility, and performance.

2. Material and Methods

Animals and treatments

The experiment was conducted at the Institute of Animal Science, Universidade Federal Rural do Rio de Janeiro (UFRRJ), Brazil, for 12 weeks during the dry season (winter). The Ethics Committee on the Use of Animals of the Institute of Animal Science, UFRRJ, approved the present study (#0028-10-2018).

Twenty non-pregnant, healthy Nellore (*Bos taurus indicus*) heifers [age, ≥18 months; initial body weight (BW), 348±30 kg (mean and standard deviation)] were used. A diet containing 70% roughage and 30% concentrate on dry matter (DM) basis was provided under two treatments: (1) control (without contamination) and (2) contaminated with ZEA. The diet was contaminated through concentrate [15 g of product contaminated with ZEA (2.56 g of ZEA/16.6 kg), equivalent to 300 ppb ZEA/heifer/day]. ZEA was obtained from an authorized establishment Contamination was performed considering the usual in commercial feedlot diets (Custódio et al. 2019); considerably less than the lethal dose for cattle, as reported by Chang et al. (2017) (>4,000 mg/kg BW). The diet was formulated according to requirements for weight gain of 1.0 kg/day (Valadares Filho et al. 2016), as shown in Table 1.

Table 1. Ingredients and chemical composition of the diet provided for beef heifers.

	g/kg	
	Concentrate	Total diet
Ingredients		
a. Roughage (corn silage)	-	700
b. Concentrate		300
b.1. Gluten meal	200	-
b.2. Corn meal	550	-
b.3. Soybean meal	200	-
b.4. Urea	10	-
b.5. Mineral mixed	40	-
Chemical composition		
Dry matter	940	506
Total digestible nutrients	780	675
Crude protein	220	115
Ether extract	35	30
Neutral Detergent Fiber	160	426

Values in dry matter basis (excepted dry matter).

Chemical analyses

Food, leftover, and fecal samples were pre-dried in an air circulation oven at 55 °C for 72 h, ground to 1.0 mm grains in a Willey-type mill, and subjected to chemical analyses. Concentrations of DM (AOAC 934.01), organic matter (OM; AOAC 942.05), crude protein (CP; AOAC 954.01), and ethereal extract (AOAC 920.29) were estimated according to AOAC (1990). Neutral detergent fiber (NDF) content was estimated as described by Mertens et al. (2002).

DM intake and digestibility

Average daily DM intake was estimated based on the difference between supply (previous day) and leftover (next day). To estimate fecal excretion, digestibility, and individual DM intake, the following markers were used: (1) external (Lipe®: 500 mg), and 2) internal (indigestible NDF), as described by Barbero et al. (2020). The external marker (capsule) was applied using a probe for 7 consecutive days in the sixth to seventh experimental week (middle of the experimental period). On the sixth, seventh, and eighth days, feces and leftovers were collected for chemical analyses in the laboratory.

Indigestible NDF was obtained after ruminal incubation in cannulated bulls for 240 h. The cannulated animals were kept in pastures under shade and provided with water and a mineral mixture *ad libitum* (housed at the São Paulo State University, Jaboticabal, Brazil, approved by the Ethics Committee on the Use of Animals, #022368/12) were collected for further laboratory analysis.

Productivity parameters

The animals were weighed weekly without fasting during 12 weeks of the experimental period. At the end of the experimental period, the heifers were transported to a commercial slaughterhouse, where they were slaughtered following the Brazilian legislation. At slaughter, carcasses were identified and carcass dressing was calculated.

Experimental design and statistical analysis

A completely randomized design was adopted. Each animal was considered one experimental unit (10 per treatment, n=20). Assumptions for variance analysis (normality of errors, independence of errors, and homogeneity of variances) were tested. Average daily gain was analyzed adopting repeated measures over time procedures, and the covariance matrix structure was chosen using the Akaike information criterion (AIC). All analyses were performed adopting a probability of 0.05 (p<0.05) using RStudio (2019).

3. Results

There were no differences in DM (p=0.9601) and NDF (p=0.9947) intake between heifers receiving the control or ZEA-contaminated diet (Table 2). Moreover, DM intake did not affect OM or CP content (p≥0.9214). There were no effects of time or interactions between time and treatments on average daily gain (p≥0.7437). Similarly, there were no differences in DM (p=0.6164) and NDF (p=0.6192) digestibility between heifers receiving the control or ZEA-contaminated diet. Final weight (p=0.8340), average daily weight gain (p=0.6796), and carcass dressing (p=0.1698) did not differ between heifers receiving the control or ZEA-contaminated diet (Table 2).

Table 2. Intake, digestibility and productive parameters by feedlot beef heifers receiving a diet contaminated with Zearalenone.

	Treatment		SEM	*p*-value
	Control[1]	Zea[2]		
Intake				
Dry matter (% of body weight)	2.46	2.68	0.19	0.9601
Neutral detergent fiber (% of body weight)	1.18	1.28	0.09	0.9947
Digestibility				
Dry matter (%)	70.77	70.97	1.82	0.6164
Neutral detergent fiber (%)	65.54	65.50	0.36	0.6192
Productive parameters				
Final body weight (kg)	443	441	4.52	0.8340
Average daily gain (kg/day)	1.15	1.11	0.07	0.6796
Carcass dressing (%)	51.40	51.30	0.01	0.1698

Standard error of mean (SEM); [1] Control: corn silage + concentrate, without Zearalenone (10 heifers); [2] Zea: Corn silage + concentrate, contaminated with Zearalenone, 300 ppb (10 heifers).

4. Discussion

Increased DM intake increases nutrient intake, ultimately improving cattle performance (Barbero et al. 2020); however, this is limited by the nutritional value and even by the presence of antinutritional factors, such as mycotoxins (Custódio et al. 2019). DM intake of highly selective animals, such as poultry and small ruminants, decreases when the food is contaminated by mycotoxins (Tola and Kebede 2016).

Furthermore, Chang et al. (2017) have reported a wide variation in the degree of contamination with ZEA in different types of feed for cattle, poultry, and pigs, with an average contamination of 70 µg/kg. They also identified cases of contamination of beef cattle diets (510 µg/kg). The authors attributed greater resistance of ruminants to mycotoxins than that of poultry and pigs to this observation.

According to Fink-Gremmels (2008), the rumen environment may be responsible for inactivating most of the ingested mycotoxins. Following ingestion, a large portion of ZEA is subjected to the actions of rumen protozoa and is converted into α-zearalenol, which produces a greater estrogenic effect than its original form. However, α-zearalenol has a lower absorption rate, producing fewer adverse effects. When absorbed, α-zearalenol is converted to β-zearalenol in the liver, and it is toxic to endometrial cells (Kiessling et al. 1984). Therefore, ruminants are apparently less susceptible to the detrimental effects of mycotoxins when they eat contaminated diets. In the present study, no significant effects of ZEA contamination of diet for heifers on their intake and digestibility were detected, possibly as the degree of contamination was rather low to cause adverse effects in cattle and as ruminants are more resistant to the adverse effects of mycotoxins.

Custódio et al. (2019) reported that a specific mycotoxin is rarely found in animal feed and combinations of different types are more common. The combined effects of two or more mycotoxins may compromise animal health, thereby negatively affecting productivity indices. Of note, in the present study, a single mycotoxin was exogenously supplemented to the diet, as no mycotoxin was detected in the samples of feed provided.

5. Conclusions

In the present study, despite receiving ZEA-contaminated diet, the evaluated heifers showed high weight gain (approximately 1 kg/day), compatible with the nutritional requirements considered in the diet formulation and nutrient intake. Therefore, the tested animals were healthy, which may explain the limited possible negative effects of mycotoxin contamination of animal diets. The experimental hypothesis was rejected. Contamination of diet by 300 ppb ZEA did not lead to detrimental effects on the intake, digestibility, and performance of healthy, feedlot-finished beef heifers.

Authors' Contributions: PIÃO, D.O.: acquisition of data, analysis and interpretation of data and drafting the article; DE MELLO, M.R.B.: conception and design and critical review of important intellectual content; BARBERO, M.M.D.: critical review of important intellectual content; DA SILVA, A.L.: critical review of important intellectual content; MOURA, A.M.: critical review of important intellectual content; BARBERO, R.P.: conception and design, analysis and interpretation of data and critical review of important intellectual content. All authors have read and approved the final version of the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

Ethics Approval: The Ethics Committee on the Use of Animals of the Institute of Animal Science, UFRRJ, approved the present study (#0028-10-2018).

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