Homeopathic additives and virginiamycin® in grazing beef cattle

Josilaine Aparecida da Costa Lima, Henrique Jorge Fernandes, Aline Gomes da Silva, Edneia Pereira Rosa and Yasmin dos Santos Falcão

ABSTRACT - The aim of this study was to evaluate the effects of homeopathic additives and the non-ionophore antibiotic virginiamycin® on intake, digestibility, metabolic characteristics and carcase characteristics in Nellore bulls under supplemented grazing. Twelve uncastrated Nellore bulls were used, with an initial mean weight of 346.04 ± 13.33 kg and initial age of 20.00 ± 2.00 months. The animals were kept in individual paddocks of *Urochloa decumbens* Stapf. (syn. *Brachiaria*) and divided into two treatments: Lipomax® - supplement concentrate with homeopathic additives (Convert H®, Sodo 100®, Figotonus®) and a non-ionophore antibiotic (Virginiamycin®); Control - supplement concentrate containing the same protein content, but with no additives. The experiment was carried out in a completely randomised design. Intake, the apparent digestibility of the dietary constituents and the metabolic characteristics of the bulls were not affected by supplementation with additives (P>0.05). Lipomax® improved weight gain in the animals (P<0.05) and the hot and cold carcase weight was also higher in animals supplemented with Lipomax® (P<0.05). The proportion of muscle and fatty tissue in the carcase was not affected by supplementation with additives (P>0.05). Supplementation with homeopathic additives and virginiamycin® had a positive effect on performance and on hot and cold carcase weight in grazing Nellore bulls.

Key words: Antibiotic. Nellore. Pasture. Supplement.

RESUMO - O objetivo com este trabalho foi avaliar os efeitos de aditivos homeopáticos associados ao antibiótico não ionóforo virginiamicina® sobre o consumo, a digestibilidade, as características metabólicas e as características de carcaça de tourinhos Nelore suplementados em pastejo. Foram utilizados 12 tourinhos Nelore, não castrados, com peso inicial médio de 346,04 ± 13,33 kg e idade inicial de 20,00 ± 2,00 meses. Os animais foram alojados em piquetes individuais de *Urochloa decumbens* Stapf. (syn. *Brachiaria*), e divididos em dois tratamentos: Lipomax®, suplemento concentrado com aditivos homeopáticos (Convert H®, Sodo 100®, Figotonus®) e antibiótico não ionóforo (Virginiamicina®); e Controle - suplemento concentrado com mesmo teor de proteína, sem aditivos. O experimento foi conduzido em delineamento inteiramente casualizado. O consumo, a digestibilidade aparente dos constituintes da dieta e as características metabólicas dos tourinhos não foram afetados pela suplementação com aditivos (P>0,05). O Lipomax® melhorou o ganho de peso dos animais (P<0,05). O peso de carcaça quente e fria também foram maiores nos animais suplementados com Lipomax® (P<0,05). As proporções de músculo e tecido adiposo na carcaça não foram afetadas pela suplementação com aditivos (P>0,05). A suplementação com aditivos homeopáticos associados a virginiamicina® afetaram de maneira positiva o desempenho e o peso de carcaça quente e fria de tourinhos Nelore em pastejo.

Palavras-chave: Antibiótico. Nelore. Pastagem. Suplemento.

DOI: 10.5935/1806-6690.20200026

*Author for correspondence

Received for publication in 14/10/2018; approved in 16/10/2019

1Part of the Doctoral Thesis of the first author

Universidade Federal do Mato Grosso do Sul/UFMS, Campo Grande-MS, Brasil, josilainelima.zootecnia@yahoo.com.br (ORCID ID 0000-0001-6835-5818), alinegomesdasilva@rocketmail.com (ORCID ID 0000-0001-9174-1434), neiaros@hotmail.com (ORCID ID 0000-0002-2284-2773)

Universidade Estadual do Mato Grosso do Sul/UEMS, Aquidauana-MS, Brasil, henrique.uems@hotmail.com (ORCID ID 0000-0001-7617-9711), yasmin_sfalciao2@hotmail.com (ORCID ID 0000-0001-7789-8718)
INTRODUCTION

In the search for tools that help maximise results and improve financial return from livestock activity, additives are used to manipulate rumen fermentation and increase the efficiency of nutrient digestion and absorption (BENATTI et al., 2017; SOLOMON; TULLETT, 1988). Hao et al. (2014) pointed out that the use of additives is an increasingly common tool in production systems as a way of reducing costs, improving feed conversion and weight gain, and/or benefiting the health and metabolism of the animal, thereby contributing to better performance, especially during the growth phase and termination.

Virginiamycin® is a non-ionophore antibiotic produced from the fermentation of Streptomyces virginae. It shows great potential for stabilising rumen fermentation by changes in the population of rumen bacteria, besides having greater control over the production of lactate and methane, as it acts directly on the species that produce these compounds (LEMOS et al., 2016; NAGARAJA; TAYLOR, 1987; OLIVEIRA et al., 2017). Due to these characteristics, virginiamycin® has been used to adapt animals to high-concentrate diets (LEMOS et al., 2016; MONTANO et al., 2015), reducing the risk of metabolic disorders. On the other hand, the results of using this compound in roughage-based diets have not yet been consolidated (ALVES NETO et al., 2018; FERREIRA et al., 2015).

By contrast, homeopathy is a therapeutic technique whose basic principle is ‘like curing like’ and the use of dynamised medicines, i.e. medicines prepared from plant, animal or mineral substances (GEMELLI; PEREIRA, 2018). Its mechanism of action involves highly complex physical manifestations, and it is characterised by the use of medicines at minimal doses (EBERT et al., 2017). In animal nutrition, homeopathy has been used to promote animal performance, substituting the use of chemotherapeutics (CHABEL et al., 2009; ITAVO et al., 2010; MARAFON et al., 2014).

However, results evaluating the use of homeopathy together with non-ionophore antibiotics are still relatively scarce and contradictory. As such, the aim of this study was to evaluate the effects of Lipomax® commercial supplement concentrate, which includes in its composition, homeopathic additives (Convert H®, Sodo 100®, Figotonus®) and virginiamycin® non-ionophore antibiotic, on intake, the digestibility of dietary constituents, and the metabolic and carcass characteristics of Nellore bulls under supplemented grazing.

MATERIAL AND METHODS

This study complies with the rules and standards of the Ethics Committee on the Use of Animals of the State University of Mato Grosso do Sul (No 01/2016).

The experiment was conducted on the Aquidauana Campus of the State University of Mato Grosso do Sul. A 12-hectare area of Urochloa decumbens Stapf. (syn. Brachiaria) was used, which was divided into 12 paddocks, each of 1.00 hectare, where 12 individual uncastrated Nellore bulls were kept, with an initial mean weight of 346.04 ± 13.33 kg and initial age of 20.00 ± 2.00 months.

The experiment was conducted in a completely randomised design with six experimental units (animals) per treatment. After initial weighing, the animals were randomly divided into two treatments: six animals received Lipomax® commercial supplement concentrate with homeopathic additives (Convert H®, Sodo 100®, Figotonus®) and virginiamycin® non-ionophore antibiotic throughout the experimental period (Lipomax®). The remaining animals received supplement concentrate containing the same protein content (Table 1), but with no additives (Control). The supplement concentrate used in the Control treatment was formulated with maize, soya meal, cottonseed, vegetable oil and urea.

The supplements were offered daily at 10:00, in an amount equal to 0.5% of body weight. To adjust the amount of supplement offered, the animals were weighed every 28 days without fasting. The animals were also weighed after a liquid fast of 16 hours at the beginning and end of the experiment to evaluate the average daily gain (ADG). The experiment lasted for 100 days.

Forty-five days after the beginning of the experiment, a digestibility trial was carried out to evaluate intake and nutritional characteristics. LIPE®, supplied to the animals via oesophageal probe as one 500-mg capsule per day, was used to estimate faecal production (SILVA et al., 2010). The intake of supplement concentrate was determined from the difference in weight of the offered supplements and the daily quantity of leftovers. Indigestible neutral detergent fibre (iNDF) was used as an internal indicator to estimate forage intake (DETMANN et al., 2001).

The digestibility trial lasted for seven days. The LIPE® was applied between day one and day five. On day four of the trial, forage was collected in each paddock, in a simulation of manual grazing, to estimate the intake and apparent digestibility coefficients of the forage. Faeces were collected in the stable directly from the rectum of the animals, between day three and day six of the trial. The faeces were collected once a day for four days at different times (06:00, 10:00, 14:00 and 17:00) to obtain a composite sample.
On the seventh and last day of the trial to evaluate the nutritional characteristics, spot urine samples were collected from spontaneous urination, and blood samples by jugular venepuncture, four hours after offering the supplement. The urine samples were diluted in H$_2$SO$_4$ (0.036 N) and frozen at -20 °C (VALADARES et al., 1999), for later analysis to determine the creatinine, urea and total nitrogen. The blood samples were collected immediately after collecting the urine and sent to the laboratory for serum urea analysis. Creatinine was quantified using the kinetic colorimetric method; the levels of urinary and serum urea were determined using the fixed-time kinetic method.

The samples of forage and faeces were dried in a forced ventilation oven (55 °C/72 hours) and processed in a knife mill (1 mm). The samples of forage, supplement and faeces were evaluated for dry matter (DM, method INCT-CA G-003/1), mineral matter (MM, method INCT-CA M-001/1), crude protein (CP, method INCT-CA N-001/1), ether extract (EE, method INCT-CA G-005/1), neutral detergent fibre (NDF, method INCT-CA F-002/1) corrected for ash (NDIA, method INCT-CA M-002/1) and protein (NDIP, method INCT-CA N-004/1), and indigestible neutral detergent fibre (NDFi, method INCT-CA F-009/1) as per the techniques described by Detmann et al. (2012). The non-fibrous carbohydrate (NFC) content was estimated as per Detmann and Valadares Filho (2010):

$$\text{NFC} = 100 - (\% \text{CP} - \% \text{CPu} + \% U) + \% \text{NDFap} + \% \text{EE} + \% \text{MM})$$

where: \( \text{CPu} \) = urea; \( \text{CP} \) content; \( U \) = urea content.

The forage dry matter intake (FDMI) was estimated by using NDFi as an internal marker, adjusting the equation proposed by Detmann et al. (2001):

$$\text{FDMI (kg day}^{-1}) = \left(\frac{\text{DMF x NDFi}}{\text{faeces}} - \left(\frac{\text{DMi}}{\text{supl}} \times \frac{\text{NDFi}}{\text{supl}}\right)\right) / \text{NDFi forage}$$

where: DMF = faecal dry matter (kg day$^{-1}$); NDFi$_{faeces}$ = indicator concentration in the faeces; DMi$_{supl}$ = supplement dry matter intake (kg); NDFi$_{supl}$ = indicator concentration in the supplement; NDFi$_{forage}$ = indicator concentration in the forage.

When the animals reached a mean weight of 450 kg, they were transported to an industrial slaughterhouse 10 km away.
from the experimental site. During pre-slaughter management at the slaughterhouse, the animals were fasted for 24 hours. The animals were stunned by brain concussion, followed by sectioning of the jugular vein, removal of the hide, and evisceration. After evisceration, the liver was collected and washed prior to weighing.

The carcases were identified, divided into two halves with the help of an electric saw and weighed to obtain the hot carcase weight, after which the hot carcase yield was determined. After the slaughter process, the carcases were taken to the cold room where they remained for 24 hours at a temperature of -5 °C; the cold carcase weight and cold carcase yield were then taken.

Carcase length was measured on the left half-carcase of each animal, from the anterior edge of the pubis bone to the medial cranial edge of the first rib. A perpendicular cut was also made in the Longissimus dorsi muscle on the left half-carcase, between the 12th and 13th ribs, where the subcutaneous fat thickness was measured with the aid of a digital caliper.

To evaluate the colour of the meat and fat, a portable colorimeter was used as per the HunterLab colour system, whose coordinates L, a and b indicate respectively: the luminosity, which is influenced by the amount of water on the surface of the meat, a result of the water retention capacity and the amount of fat; the red content, which reflects the amount of red pigment present in the myoglobin and cytochrome C; and the yellow content, which is associated with the presence of carotenoids. Three colour readings were taken on the Longissimus dorsi muscle in the region of the 13th rib of the left half-carcase of each animal.

The proportion of muscle, fatty tissue and bone on the carcass was estimated by physically separating the section corresponding to the 9th, 10th and 11th ribs from the left half-carcase, known as the HxH section, following the procedure described by Hankins and Howe (1946). The proportions in the carcase were estimated as per the equations developed by the above authors:

\[
\text{Proportion of muscle } Y = 16.08 + 0.80 X \quad (1)
\]
\[
\text{Proportion of fatty tissue } Y = 3.54 + 0.80 X \quad (2)
\]
\[
\text{Proportion of bone } Y = 5.52 + 0.57 X \quad (3)
\]

where: X is the percentage of the corresponding component in the HxH section.

To evaluate the weight and feed conversion data, the PROC MIXED procedure of the SAS University software (SAS Institute Inc., Cary, CA, USA) was used. The PROC GLM procedure was used to evaluate the other performance data, nutritional characteristics and carcass data. The mean values of the treatments were compared by t-test at a significance level of 5%.

**RESULTS AND DISCUSSION**

It is important to point out that the animals did not suffer any environmental or health challenge during the experimental period which could have intensified the performance of the homeopathic products used, since one of the functions of these products is to control the adverse effects of stress.

The total consumption of forage dry matter, concentrate dry matter and total dry matter did not vary (P>0.05) between treatments (Table 2). According to Alves Neto et al. (2018), virginiamycin® is an additive with little or no effect on intake, having a greater effect on rumen fermentation. There was no significant difference between the treatments under evaluation (P>0.05) for the roughage to concentrate ratio. In the Control treatment, supplement intake corresponded to 9% of the total DM intake; in the Lipomax® treatment this was equal to 14%.

There was a significant difference between treatments (P<0.05) for the consumption of ether extract (EE). This seems to have been caused by the higher concentration of this component in the supplement of the Control treatment, as it included cottonseed and vegetable oil among its ingredients.

The consumption of crude protein (CP), neutral detergent fibre corrected for ash and protein (NDFap), non-fibrous carbohydrates (NFC) and total digestible nutrients was similar between treatments (P>0.05), due to the similarity of the composition and consumption of the supplement concentrates.

EE digestibility was higher in the diet of animals fed the Control treatment (P<0.05; Table 3), which can be explained by the greater consumption of this component in this treatment. However, the digestibility coefficients for CP, NDFap and NFC were similar between diets (P>0.05).

The similarity between the concentration of blood urea nitrogen, urine urea nitrogen and total urinary nitrogen in both treatments (P>0.05), shows that the usage efficiency of the metabolisable protein intake was similar between treatments (Table 4).

Although there was no difference in intake, digestibility or nitrogen use in the animals of either treatment, those that received Lipomax® showed a higher (P<0.05) average daily gain and, consequently, greater (P<0.05) final weight. As a result, the animals that received Lipomax® weighed around 30 kg more by the end of the experiment than those in the Control treatment (Table 5).
Increased weight gain is an expected result of the use of additives. According to Ferreira et al. (2015), among the positive effects of virginiamycin®, increased weight gain in the animals stands out. The use of homeopathic additives to promote animal growth still gives contradictory results, however their use is intended to reduce the stress in animals caused by improper handling or even by nutritional

### Table 2 - Ingestive characteristics of bulls receiving concentrate supplement with or without Lipomax® additives

| Parameter                          | Treatment   | C.V., % | P-value |
|-----------------------------------|-------------|---------|---------|
|                                   | Control     | Lipomax®|         |
|                                   | kg d⁻¹      |         |         |
| Forage dry matter¹                | 8.42        | 7.99    | 15.10   | 0.561   |
| Concentrate dry matter¹           | 0.84        | 1.27    | 51.07   | 0.205   |
| Total dry matter¹                 | 9.26        | 9.26    | 12.68   | 0.996   |
| Roughage:Concentrate ratio²       | 91.09       | 86.14   | 6.66    | 0.169   |
| Ether extract¹                    | 0.34        | 0.23    | 19.46   | 0.006   |
| Crude protein¹                    | 0.86        | 0.83    | 22.05   | 0.797   |
| NDFap¹                            | 5.92        | 5.67    | 15.43   | 0.634   |
| Non-fibrous carbohydrates¹        | 1.37        | 1.72    | 19.81   | 0.072   |
| Total digestible nutrients¹       | 6.38        | 6.18    | 16.36   | 0.746   |
|                                   | g kg⁻¹ BW   |         |         |
| Total dry matter¹                 | 21.34       | 22.27   | 12.90   | 0.578   |
| Forage dry matter¹                | 18.47       | 20.30   | 17.57   | 0.374   |
| NDFap¹                            | 14.28       | 13.12   | 17.99   | 0.433   |

NDFap = neutral detergent fibre corrected for ash and protein; ¹Estimated values for intake; ²in % pasture

### Table 3 - Apparent digestibility coefficient (%) of the dietary components of bulls receiving supplement concentrate with or without Lipomax® additives

| Parameter            | Treatment | C.V., % | P-value |
|----------------------|-----------|---------|---------|
|                      | Control   | Lipomax®|         |
| Ether Extract        | 79.00     | 67.90   | 7.19    | 0.004   |
| Crude protein        | 78.10     | 74.90   | 7.46    | 0.359   |
| NDFap¹               | 68.40     | 67.60   | 7.88    | 0.817   |
| Non-fibrous carbohydrates | 73.90     | 74.20   | 11.41   | 0.949   |

¹Neutral detergent fibre corrected for ash and protein

### Table 4 - Blood urea nitrogen, urine urea nitrogen and total urinary nitrogen in bulls receiving supplement concentrate with or without Lipomax® additives

| Parameter             | Treatment | C.V., % | P-value |
|-----------------------|-----------|---------|---------|
|                      | Control   | Lipomax®|         |
| Blood urea nitrogen¹  | 15.12     | 14.75   | 10.38   | 0.690   |
| Urine urea nitrogen²  | 35.89     | 33.01   | 28.62   | 0.622   |
| Total urinary nitrogen² | 45.88     | 55.12   | 24.85   | 0.231   |

¹in mg dl⁻¹; ²in g d⁻¹
imbalance (GEMELLI; PEREIRA, 2018), and has a positive impact on animal performance (RIBEIRO et al., 2011; SILVA et al., 2011).

Little is known about the action of homeopathic products on animal physiology. However, according to Gemelli and Pereira (2018), homeopathic products can affect the hypothalamic-pituitary-adrenal axis, where the energy information of these products is sensed or captured by nerve endings in the mucosa of the mouth and the digestive tract. Once captured, this energy information reaches the central nervous system, triggering corrective or stimulatory actions that result in improved productivity.

Among the additives included in the Lipomax® treatment, the aim of Convert H® is to make the animal less reactive to situations that cause stress, and improve feed conversion (MARAFON et al., 2014) by altering the metabolism of the absorbed nutrients. The greater weight gain for a similar intake seen here, seems to confirm these assumptions, although the presence of additives in the supplement has shown only a tendency (0.05 < P < 0.10) to significantly affect feed conversion.

With the carcase characteristics, there was a significant increase in hot and cold carcase weight for the Lipomax® treatment compared to the Control (P<0.05; Table 6). As animals that received the Lipomax® treatment had a greater final weight, their carcasses were expected to be heavier.

However, the difference in slaughter weight seen between animals that received the Lipomax® treatment and those that received the Control, was not enough to significantly increase (P>0.05) carcase yield. The greater carcase yield that is expected as the animals become larger (BERG; BUTTERFIELD, 1976), is only seen when there is a greater difference in slaughter weight among the animals. There was no significant difference between treatments in terms of subcutaneous fat thickness, liver weight or carcase length (P>0.05).

The colour of the meat, although not influencing sensory or palatability characteristics, is an important factor in the purchase decision of the consumer. Carotenoids, a group of pigments present in nature, in addition to contributing to the colour and nutritional quality of food, have also been used to indicate animals finished on pasture, since the presence of these compounds in the cattle carcase is directly linked to their intake (ÁLVAREZ et al., 2015).

The meat colour in the animals that received Lipomax® had a lower (P<0.05) value for b. The b parameter indicates the yellow intensity, which is usually set by the number of carotenoids in the pasture. As pasture intake was similar in both treatments, this may indicate less absorption and deposition of these compounds in the meat due to the use of the additives under evaluation. However, no account was found in the literature that pointed out this effect when using any of the additives evaluated here. The treatments evaluated in the present experiment were unable to effectively alter (P> 0.05) the other parameters of meat or fat colour.

The estimated amounts of muscle and fatty tissue in the carcase did not differ (P> 0.05) with the use of additives in the concentrate (Table 7).

The greater (P<0.05) amount of bone in the animals that received the additives (Lipomax®), together with the similarity in carcase size, points to a physiological effect that seems to increase bone density, probably due to a greater deposition of minerals in the bones.

In studies with non-ruminant animals, it was found that virginiamycin® can have a positive effect on the growth of intestinal microviliocities, increasing the sites of nutrient absorption (LINDEMANN et al., 2010; McCORMICK et al., 2016; STEWART et al., 2010). In high-fibre diets (RAVINDRAN et al., 1984), virginiamycin® also acts on the retention time of nutrients in the gastrointestinal tract, which may have increased the absorption of some minerals, such as calcium and phosphorus, thereby increasing bone density, as seen in this study.

### Table 5 - Performance of bulls receiving concentrate supplement with or without Lipomax® additives

| Parameter                  | Treatment       | C.V., % | P-value |
|----------------------------|-----------------|---------|---------|
|                            | Control         | Lipomax® |         |         |
| Initial weight<sup>1</sup> | 343.70          | 348.40  | 3.97    | 0.563   |
| Final weight<sup>1</sup>   | 428.80          | 459.10  | 4.71    | 0.033   |
| Average daily gain<sup>2</sup> | 0.85         | 1.11    | 19.50   | 0.047   |
| Feed conversion<sup>3</sup> | 11.30          | 8.60    | 23.70   | 0.069   |

<sup>1</sup> in kg; <sup>2</sup> in kg d<sup>-1</sup>; <sup>3</sup> in kg kg<sup>-1</sup>
Table 6 - Carcass characteristics of bulls receiving concentrate supplement with or without Lipomax® additives

| Parameter            | Treatment     | C.V., % | P-value |
|----------------------|---------------|---------|---------|
|                      | Control       | Lipomax® |         |
| Hot carcase weight¹  | 242.00        | 255.00  | 3.74    | 0.039   |
| Hot carcase yield²   | 56.40         | 55.60   | 3.31    | 0.471   |
| Cold carcase weight¹ | 236.00        | 249.00  | 3.88    | 0.040   |
| Cold carcase yield²  | 55.10         | 54.30   | 2.77    | 0.391   |
| Carcase length³      | 125.00        | 125.00  | 2.27    | 0.492   |
| Fat thickness⁴       | 3.56          | 3.00    | 31.50   | 0.371   |
| Liver weight¹        | 4.75          | 5.03    | 8.74    | 0.283   |

| Colour of the meat   |               |         |         |
|----------------------|---------------|---------|---------|
| L                    | 36.90         | 61.10   | 3.55    | 0.813   |
| a                    | 19.30         | 17.30   | 9.11    | 0.068   |
| b                    | 16.00         | 14.00   | 7.11    | 0.009   |

| Colour of the fat    |               |         |         |
|----------------------|---------------|---------|---------|
| L                    | 61.00         | 61.10   | 7.51    | 0.980   |
| a                    | 19.60         | 17.40   | 28.00   | 0.478   |
| b                    | 26.50         | 24.00   | 12.30   | 0.183   |

¹ in kg; ² in % fasted body weight; ³ in cm; ⁴ in mm

Table 7 - Tissue estimate in the carcase of bulls receiving concentrate supplement with or without Lipomax® additives

| Parameter         | Treatment     | C.V., % | P-value |
|-------------------|---------------|---------|---------|
|                   | Control       | Lipomax® |         |
| Muscle¹           | 161.00        | 168.00  | 6.83    | 0.264   |
| Bone¹             | 34.50         | 38.70   | 7.65    | 0.027   |
| Fatty tissue¹     | 50.70         | 50.80   | 16.40   | 0.983   |

¹ in kg

CONCLUSION

Supplementation using homeopathic additives and non-ionophore antibiotics improves the performance and hot and cold carcase weight of grazing Nellore bulls.

ACKNOWLEDGEMENTS

The authors would like to thank the Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT) and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) - Finance Code 001. The authors also wish to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Real H – Nutrition and Animal Health, for their support in carrying out this study.

REFERENCES

ÁLVAREZ, R. et al. Carotenoid and vitamin A contents in biological fluids and tissues of animals as an effect of the diet: A review. Food Reviews International, v. 31, p. 319-340, 2015.

ALVES NETO, J. A. et al. Determining the optimal dose of virginiamycin for ruminal parameters and performance of Nellore cattle on pasture. Semina: Ciências Agrárias, v. 39, n. 4, p. 1749-1758, 2018.

BENATI, J. M. B. et al. Effect of increasing monensin sodium levels in diets with virginiamycin on the finishing of Nellore cattle. Journal of Animal Science, v. 88, p. 1709-1714, 2017.

BERG, R. T.; BUTTERFIELD, R. M. New concepts of cattle growth. Sydney: Sydney University Press. 1976. 255 p.

CHABEL, J. C. et al. Efeito de um complexo homeopático “Homeobase Convert H®” em ovinos sob condições de restrição alimentar. Brazilian Journal of Veterinary Research and Animal Science, v. 46, n. 5, p. 412-423, 2009.
DETMANN, E. et al. Cromo e indicadores internos na estimação do consumo de novilhos mestiços, suplementados, a pasto. Revista Brasileira de Zootecnia, v. 30, n. 5, p. 1600-1609, 2001.

DETMANN, E. et al. Métodos para análise de alimentos - INCT - Ciência Animal. Visconde do Rio Branco, MG: Suprema. 2012. 214 p.

DETMANN, E. et al. Cromo e indicadores internos na estimação do consumo de novilhos mestiços, suplementados, a pasto. Revista Brasileira de Zootecnia, v. 30, n. 5, p. 1600-1609, 2001.

DETMANN, E.; VALADARES FILHO, S. C. Métodos para análise de alimentos - INCT - Ciência Animal. Visconde do Rio Branco, MG: Suprema. 2012. 214 p.

DETMANN, E. et al. On the estimation of non-fibrous carbohydrates in feeds and diets. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, v. 62, n.4, p. 980-984, 2010.

DETMANN, E. et al. Desempenho e metabolismo ruminal em bovinos de corte em sistema de pastoreio no período seco do ano recebendo virginiamicina na dieta. Semina: Ciências Agrárias, v. 36, n. 3, p. 2067-2078, 2015.

DETMANN, E. et al. Homeopatia na terminação de novilhos Nelores e Tabapuãs confinados. Agropecuária Científica no Semi-Árido, v. 7, n. 1, p. 38-44, 2011.

HANKINS, O. G.; HOWE, P. E. Estimation of the composition of beef carcass and cuts. USDA: Washington, 1946. (Technical Bulletin, 926), 26 p.

HAO, H. et al. Benefits and risks of antimicrobial use in food-producing animals. Frontiers in Microbiology, v. 5, p. 1-11, 2014.

IITAVO, L. C. V. et al. Homeopatia na terminação de novilhos em confinamento. Archivos de Zootecnia, v. 59, n. 226, p. 225-232, 2010.

LEMOS, B. J. M. et al. Monensin, virginiamycin, and flavomycin in a no-roughage finishing diet fed to zebu cattle. Journal of Animal Science, v. 94, p. 4307-4314, 2016.

LINDEMANN, M. D. et al. Evaluation of antibiotic effects on phosphorus digestibility and utilization by growing-finishing pigs fed a phosphorus-deficient, corn-soybean meal diet. Journal of Animal Science, v. 88, p. 1752-1758, 2010.

MARAFON, F. et al. Homeopatia e desempenho de novilhos confinados com dieta 100% ou 48% de concentrado. Archivos de Zootecnia, v. 63, n. 241, p. 199-202, 2014.

McCORMICK, K. et al. Phosphorus utilization response of pigs and broiler chickens to diets supplemented with antimicrobials and phytase. Animal Nutrition, v. 1, p. 1-8, 2016.

MONTANO, M. F. et al. Effects of monensin and virginiamycin supplementation in finishing diets with distiller dried grains plus solubles on growth performance and digestive function of steers. Journal of Applied Animal Research, v. 43, n. 4, p. 417-425, 2015.

NAGARAJA, T. G.; TAYLOR, M. B. Susceptibility and resistance of ruminal bacteria to antimicrobial feed additives. Applied and Environmental Microbiology, v. 53, n. 7, p. 1620-1625, 1987.

OLIVEIRA, V. S. et al. Estratégias para mitigar a produção de metano entérico. Veterinária Notícias, v. 23, n. 1, p. 39-70, 2017.

RAVINDRAN, V. et al. Effects of fibre and virginiamycin on nutrient absorption, nutrient retention, and rate of passage in growing swine. Journal Animal Science, v. 59, p. 400-408, 1984.

RIBEIRO, J. S. et al. Homeopatia na terminação de novilhos Nelores e Tabapuãs confinados. Agropecuária Científica no Semi-Árido, v. 7, n. 1, p. 38-44, 2011.

SILVA, J. J. et al. Indicadores para estimativa de consumo total por novilhos holandeses e zebu mantidos em confinamento. Revista Brasileira de Saúde e Produção Animal, v. 11, n. 3, p. 838-848, 2010.

SILVA, J. R. M. et al. Suplementação de vacas leiteiras com homeopatia: desempenho e digestibilidade. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, v. 63, n. 4, p. 922-930, 2011.

SOLOMON, S. E.; TULLETT, S. G. The effect of virginiamycin on the ileum of the domestic fowl. 1. Light and scanning electron microscope observations. Animal Technology, v. 39, p. 157-160, 1988.

STEWART, L. L. et al. Effect of virginiamycin on the apparent ileal digestibility of amino acids by growing pigs. Journal of Animal Science, v. 88, p. 1718-1724, 2010.

VALADARES, R. F. D. et al. Effect of replacing alfalfa silage with high moisture corn on ruminal protein synthesis estimated from excretion of total purine derivatives. Journal of Dairy Science, v. 82, p. 2686-2696, 1999.