DOI: 10.5433/1679-0359.2018v39n1p261

Effect of monensin sodium associative to virginiamycin and/or essential oils on the performance of feedlot finished steers

Efeito associativo da monensina sódica à virginiamicina e/ou óleos essenciais sobre o desempenho de novilhos terminados em confinamento

Julio Cezar Heker Junior[1*]; Mikael Neumann[2]; Robson Kyoshi Ueno[3]; Margarete Kimie Falbo[4]; Sandra Galbeiro[5]; André Martins de Souza[6]; Bruno José Venancio[7]; Leslei Caroline Santos[7]; Eloize Jaqueline Askel[6]

Abstract

The objective of this study was to evaluate the associative effect of monensin sodium to virginiamycin and/or essential oils on performance, consumption of nutrients and dry matter, apparent digestibility, feeding behavior and carcass characteristics of feedlot finished steers. The experiment lasted 106 days with 10 days of adaptation and 96-day trial, and had 32 crosses angus steers, average age 12 months and average weight of 376 kg, divided into 16 stalls, the weighing took place every 21 days and at the end of the experiment. The treatments consisted of the combination of the following additives to the diet included: Monensin sodium, 200 mg day^{-1} (MO); Monensin sodium, a dose of 200 mg day^{-1} + essential oil dose of 1.5g day^{-1} (MO+EO); Monensin sodium, a dose of 200 mg day^{-1} + virginiamycin, 200 mg day^{-1} (MO+VI); Monensin sodium, 200 mg day^{-1} + essential oil dose of 1.5g day^{-1} + virginiamycin day, 200 mg day^{-1} (MO+EO+VI), each treatment had four repetitions, where each repetitions consisted of a bay with two animals. The MO+VI association in relation to MO only increase in average daily gain (ADG) of 24.44%, 22.35%, 21.10% and 17.31% in weighing 42, 63, 84 and 96 days, similar the combination of MO+EO+VI which provided an improvement of 21.94%, 13.59%, 15.45% and 14.75% respectively in the same weightings. The daily carcass gain and carcass overall gain were higher in associations MO+VI and MO+EO+VI and provided an average gain of 16.67 kg more compared to MO and MO+EO. In the parameters feed efficiency, dry matter intake and nutrient expressed in kg day^{-1} and percentage of live weight were not observed differences (P> 0.05) between treatments. Data on apparent digestibility, feeding behavior and carcass characteristics did not show statistical difference between treatment, except for fat thickness which was higher when associated with any of the additives to the MO, and farm weight was higher in associations containing VI. Associating MO+VI or MO+EO+VI proved to be best in this work compared to MO+EO or only MO in the diets of steers in termination.
Key words: Ionophores. Antibiotics. Plant extracts. Performance enhancers.

[1] Médico Veterinário, Discente, Curso de Doutorado, Programa de Pós-Graduação em Produção Vegetal, Universidade Estadual do Centro-Oeste, UNICENTRO, Guarapuava, PR, Brasil. E-mail: jr_heker@hotmail.com

[2] Engº Agrº, Prof. Dr., Programa de Pós-Graduação em Ciências Veterinárias, Universidade Estadual do Centro-Oeste, UNICENTRO, Guarapuava, PR, Brasil. E-mail: neumann.mikael@hotmail.com

[3] Médico Veterinário, Prof. Dr., Curso de Medicina Veterinária, Faculdade Guarapuava, UNIGUA, Guarapuava, PR, Brasil. E-mail: robsonueno@hotmail.com

[4] Médica Veterinária, Profª Drª, Programa de Pós-Graduação em Ciências Veterinárias, UNICENTRO, Guarapuava, PR, Brasil. E-mail: margaretefalbo@hotmail.com

[5] Zootecnista, Profª Drª, Departamento de Zootecnia, Universidade Estadual de Londrina, UEL, Londrina, PR, Brasil. E-mail: sgalbeiro@gmail.com

[6] Discentes, Curso de Medicina Veterinária, UNICENTRO, Guarapuava, PR, Brasil. E-mail: andrems_92@hotmail.com; elojaque@gmail.com

[7] Médicos Veterinários, Discentes de Mestrado, Programa de Pós-Graduação em Ciências Veterinárias, UNICENTRO, Guarapuava, PR, Brasil. E-mail: bru.ze.venancio@gmail.com; lesleicaroline@hotmail.com

[*] Author for correpondence

Received: Oct. 11, 2016 - Approved: Oct. 09, 2017

Resumo

Objetivou-se avaliar o efeito associativo da monensina sódica à virginiamicina e/ou óleos essenciais sobre o desempenho, o consumo de matéria seca e de nutrientes, a digestibilidade aparente da matéria seca, o comportamento ingestivo e, as características da carcaça de novilhos terminados em confinamento. O experimento teve duração de 106 dias sendo 10 dias de adaptação e 96 dias de período experimental. Foram utilizados 32 novilhos não castrados, mestiços com predomínio da raça angus, com idade média de 12 meses e peso médio de 376 kg, distribuídos em 16 baias. Os tratamentos consistiam na associação dos seguintes aditivos inclusos as rações: Monensina sódica, dose de 200 mg.dia^{-1} (MO); Monensina sódica, dose de 200 mg.dia^{-1} + óleo essencial, dose de 1,5 g.dia^{-1} (MO+OE); Monensina sódica, dose de 200 mg.dia^{-1} + virginiamicina, dose de 200 mg.dia^{-1} (MO+VI); Monensina sódica, dose de 200 mg.dia^{-1} + óleo essencial, dose de 1,5 g.dia^{-1} + virginiamicina, dose de 200 mg/ dia-1 (MO+OE+VI), cada tratamento possuía quatro repetições, onde cada repetição era composta por uma baia com dois animais. A associação MO+VI em relação a somente MO proporcionou aumento no ganho de peso médio diário (GMD) de 24,44%, 22,35%, 21,10% e 17,31% nas pesagens de 42, 63, 84 e 96 dias, similar a associação de MO+OE+VI que proporcionaram melhora de 21,94%, 13,59%, 15,45% e 14,75% respectivamente nas mesmas pesagens. O ganho de carcaça diário e ganho de carcaça total foram superiores nas associações MO+VI e MO+OE+VI e proporcionaram ganho médio de 16,67 kg a mais em relação a MO e MO+OE. Nos parâmetros eficiência alimentar, consumo de matéria seca e nutrientes expresso em kg.dia^{-1} e em percentual de peso vivo, não foram observadas diferenças (P>0,05) significativa entre os tratamentos. Os dados referentes à digestibilidade aparente, comportamento ingestivo e características de carcaça também não apresentaram diferença estatística entre os tratamentos, exceto para espessura de gordura que foi superior quando associado qualquer um dos aditivos à MO, e peso de fazenda que foi superior nas associações que continham VI. A associação de MO+VI ou MO+OE+VI mostraram-se melhores no presente trabalho em relação a MO+OE ou somente MO nas rações dos novilhos em terminação.

Palavras-chave: Ionóforos. Antibióticos. Extratos vegetais. Melhoradores de desempenho.

Introduction

Ranching in Brazil has great respect on the world stage for animal protein production capacity, it is due to greater professionalization of producers in its activity for better results and hence more profits with activity (BRASIL, 2014).

Being one of the world leaders in the export of beef, it is linked to the great advances that have occurred in the livestock sector, a direct result of the improvements in the management and investments. The use of production systems that previously were little known and used as cattle confinement, stay themselves as indispensable strategies in order to achieve good results in the performance, cycle shortening and thus achieve greater profitability (SILVA, 2014).

According to Lopes and Magalhães (2005), the main advantages of confinement are reduced at the age of slaughter, meat production with higher quality, increase in property enjoy rate and thereby decrease the fluctuations in the supply of raw material for refrigerators in off season. There is even greater working capital, better use of pasture areas with other animal categories, full – cycle systems, and high production of organic fertilizer, but the disadvantage can be mentioned that the cost per bushel is higher, so failures in these systems should be avoided.

Ionophores are often added to the diet of livestock to facilitate higher metabolic challenge without damage to the health of the animals. Among the ionophores, monensin sodium (MO) is the most used and best studied (NUÑEZ et al., 2013).

When administered to ruminants, MO can alter the characteristics of rumen fermentation, leading to an increase in propionate production (the main precursor of glucose in ruminants) and a reduction of other volatile fatty acids, such as acetate and butyrate (RANGEL et al., 2008). Another positive effect of MO supplementation is a reduction in

ruminal protein degradation, resulting in lower losses of ammonia, enabling proteins of higher biological value to be absorbed in the intestine, thereby promoting an additional gain to the animal (ZANINE et al., 2006).

Virginiamycin (VI) Page (2003), is not an ionophore antibiotic of the class of esterptograminas produced by a mutant strain of *Streptomyces virginae* originally found in Belgian soil. It is very effective, especially in animals to adapt to diets with high concentration, which in addition to improving the health and promote the development of animals, can still benefit the environment because it acts positively on food utilization reducing losses energy in the form of gases (BATISTA et al., 2012).

According Nagaraja and Taylor (1987) it prevents the incidence of ruminites, hepatic abscesses and lactic acidosis, because they act on microorganisms that produce lactate main free hydrogen produced rumen further reduce the production of methane.

Plants, in general, have the ability to produce a range of organic compounds derived from their secondary metabolism that are classified into three main groups: saponines, tannins and essential oils. (CALSAMIGLIA et al., 2007a)

According to Calsamiglia et al. (2007b) essential oils (EO) are lipophilic, liquid and volatile substances obtained from various plant organs, the general extraction is carried out with steam or solvents, these have the capacity to act selecting the microbial populations in the rumen (BENCHAAR et al., 2008).

By changing the standard fermentation and producing more propionate, reduces the release of H^+ thereby reduce the emission of methane, which is eliminated in greater quantity when the routes used are the acetate and butyrate must therefore if maximize propionate production so there is a competition with methanogenic pathways within the rumen (VAN SOEST, 1994).

Most studies have investigated improvements in production efficiency when using a single modulator of the ruminal microflora (e.g., MO, VI or EOs); however, few studies have investigated the effects of supplementing with multiple ruminal microflora modulators simultaneously.

Here we aimed to evaluate the performance, intake of nutrients and dry matter, apparent digestibility, feeding behavior, and carcass characteristics of feedlot finished steers, evaluating the association of monensin sodium to virginiamycin and/or oils essential in the feed.

Material and Methods

The experiment was done at Animal Production Center (NUPRAN) Sector of Agricultural and Environmental Sciences of the State University of Midwest (UNICENTRO), located in Guarapuava, state of Paraná, in the period from June to October 2015.

All experimental procedures were previously submitted to the Ethics Committee on Animal Use in Experimentation (CEUA) of UNICENTRO, they have been approved for implementation (Office Nº 06/2015).

Thirty-two ½ Angus steers were used, uncastrated males, from the same herd, with initial weight of 376 ± 5 kg and average age of 12 ± 1 month. The animals were housed in 16 containment bays, semi-covered, with an area of 15 m^2 with concrete feeder and drinker regulated by float. They were previously dewormed and chosen in a herd based on weight and body condition and, then randomly distributed in a completely randomized experimental design, consisting of four treatments with four replications, which corresponded to two animals per experimental unit.

The rations were formulated according to NRC (1996) and consist of corn silage and commercial concentrate at a constant rate of 50% corn silage and 50% concentrate, on a dry basis of the experimental feed.

The concentrated mixture was prepared in commercial feed mill Agrária Cooperativa Agroindustrial, located in Guarapuava-PR, with average values of 90.37% dry matter (DM), 18.98% crude protein (CP), 22.26% of neutral detergent fiber (NDF), 9.43% acid detergent fiber (ADF), 8.48% of mineral matter (MM) and 69.03% total digestible nutrients (TDN). Corn silage was produced in the university and presented on average 31.99% DM, 6.14% CP, 48.58% of NDF, 27.03% of ADF, 1.97% MM and 68.92 TDN.

The voluntary feed intake was recorded daily by weighing the quantity supplied and the leftovers from the previous day. The adjustment of the supply amount of corn silage and concentrate was performed daily, whereas a surplus of 5% of the dry matter offered in relation to consumption.

We evaluated the dry matter intake, animal performance, apparent digestibility, feeding behavior and carcass characteristics of feedlot finished steers with the following additives included rations: Monensin, 200 mg day^{-1} (MO); Monensin, 200 mg day^{-1} + essential oil, 1.5 g dose of day^{-1} (MO+EO); Monensin, 200 mg day^{-1} + virginiamycin, 200 mg day^{-1} (MO+VI); and Monensin, 200 mg day^{-1} + essential oil dose of 1.5 g day^{-1} + virginiamycin, 200 mg day^{-1} (MO+EO+VI);

The MO-based product used was Rumensin® 200 (Elanco Animal Health, MAPA, SP-59410 30002) which is reported as enhancing animal performance. The EO-based product used was Active Premium® (120g/kg carvacrol, cineole, cinnamaldehyde, paprika oleoresin, and hydrogenated vegetable fat) (GRASP, MAPA, PR-08910 03020) which is classified as a flavoring sensory additive including a mixture of EOs in a stable microencapsulated active matrix of triglycerides. Its active compounds are natural substances found in herbs with flavoring, palatability, digestive, antioxidant, and bactericidal properties. The VI-based product used was (Eskalin® [20g/kg of virginiamycin]) (Phibro Animal Health International Ldta., MAPA, SP-09492 30012), which is classified as a performance enhancing additive composed of VI and 99% calcium carbonate.

The experiment lasted 106 days, 10 days of adaptation of animals to feed and experimental facilities and sequentially five evaluation periods. The animals were weighed in the beginning, on 21, 42, 63, 84 and at the end of the experiment, after solid fasting for 12 hours to determine the average daily gain (ADG). Rations and leftovers were weighed daily to determine the dry matter intake (DMI), allowing to obtain the daily DMI and percentage of live weight (PDMI), as well as the feed efficiency (EA [ADG:DMI]).

From the ADG data, DMI, and hot carcass weight (hCW) we calculated the total carcass gain (TCG), daily carcass gain (DCG) and efficiency in the processing of dry matter in carcass (ECT). The TGC was calculated as the difference between HCW and the initial carcass weight (iCW), which was estimated considering initial carcass yield of 50% (iCW = initial weight x 0.50). The DCG was calculated based on the period of 96 days of confinement (DCG = TCG/96). The ECT was represented by the ratio between the DCG and the DMI (ECT=DMI/DCG).

Based on daily intake and the chemical composition of feed, the intake was calculated per animal day of CP, NDF, ADF and TDN, presented in kg. day^{-1} and expressed in 100 kg of live weight.

The determination of apparent digestibility of different experimental rations were held in the middle stage of termination of animals in confinement, in which the food consumption was measured daily and three consecutive days remains, along with total collection of feces produced by animals per pen.

The animal behavior analysis was performed on a continuous period of 72 hours. The observations were performed by observers 6 per turn for 72 hours, relay system every 6 hours. Readings were taken at regular intervals of 3 minutes. The variables

analyzed in the evaluation of feeding behavior of animals, consisted of measurement of leisure activities, rumination, water intake and power, expressed in hours per day. Still were observed, following the same methodology, the frequency of occurrence of power activities, drinking water test, urination and defecation, expressed in number of times per day.

At the end of the confinement was carried out a fast solid 12 hours, heavy animals before loading to the refrigerator, where they were slaughtered. The killing followed the standards adopted by the refrigerator in accordance with the current legislation for the cattle slaughter.

The carcasses were measured in five development measures: carcass length, which is the distance between the medial cranial edge of the pubic bone and the medial cranial edge of the first rib; leg length which is the distance between the medial cranial edge of the pubic bone and the tibial articulation tarsius; and arm length, which is the distance between the tuberosity of the olecranon and radio carpal joint; arm perimeter, obtained in the middle region of the encircling arm with a tape measure; and the thickness of the cushion, measured by means of compass direction perpendicular to carcass length, taking the greatest distance between the cut that separates the two half carcasses and the lateral muscles of the thigh, as the methods suggested by Müller (1987).

The data relating to the performance, digestibility, performance and carcass characteristics were submitted to ANOVA with subsequent comparison of means by Tukey test to compare means the 5% significance through the GLM procedure of SAS statistical software (SAS, 1993). We used the following statistical model: $Y_{i} = \mu + T + {}_{i} E_{i}$ where Y_{i} = response criteria; μ = general average common to all observations (constant); T_{i} = effect of the ith treatment; and E i = random error inherent in all observations.

For performance variables and digestibility each stall (containing two animals) represented an experimental unit. The other variables the animals were to experimental units.

Results and Discussion

The ADG at the beginning of confinement (0-21dias) of steers finished evaluating the associative effect of MO to VI and/or EO in food (Table 1), was no difference (P> 0.05) between the different treatments with a average of 1.621 kg day^{-1}. With the advance of the trial period and adaptation of animals to feed, there was a positive highlight for the treatments that had the same VI in association with EO.

The MO+VI association provided an increase of 24.44% in weight 42 days, 22.35% at 63 days, 21.10% in 84 days and 17.31% at the end of the experiment in relation to the feed where there was only MO. The combination of the three additives showed no difference (P> 0.05) for both MO+VI treatment, as for the other MO+EO and MO treatments, with an addition of 21.94%, 13.59%, 15, 45% and 14.75% in weighing 42, 63, 84 and 96 days, respectively in relation to only MO. MO+EO the association also showed no difference (P> 0.05) in relation to the treatment of MO, being less numerically only weighing 96 days (1,329kg versus 1,266kg).

Table 1. Performance of steers, assessing the associative effect of monensin to virginiamycin and/or essential oils in food, according to the evaluation periods.

Parameter	Experimental Feed				Average	MSE	Prob.
	MO	MO+EO	MO+VI	MO+EO+VI			
ADG, kg day^{-1}							
d 0-21	1.500	1.571	1.720	1.690	1.621	0.0747	0.7049
d 0-42	1.440 b	1.455 b	1.792 a	1.756 a	1.611	0.0418	0.0169
d 0-63	1.427 b	1.452 b	1.746 a	1.621 ab	1.562	0.0306	0.0095
d 0-84	1.379 b	1.438 b	1.670 a	1.592 ab	1.520	0.0356	0.0473
d 0-96	1.329 bc	1.266 c	1.559 a	1.525 ab	1.420	0.0259	0.0038
FE, kg kg							
d 0-21	0.175	0.178	0.196	0.189	0.185	0.0095	0.8436
d 0-42	0.165	0.160	0.195	0.191	0.178	0.0054	0.0924
d 0-63	0.160	0.158	0.186	0.174	0.169	0.0038	0.0784
d 0-84	0.151	0.153	0.172	0.168	0.161	0.0041	0.2196
d 0-96	0.145 ab	0.134 b	0.160 a	0.159 a	0.150	0.0025	0.0089
DMI, kg day^{-1}							
d 0-21	8.58	8.82	8.89	8.96	8.81	0.1363	0.7748
d 0-42	8.75	9.11	9.26	9.22	9.08	0.1389	0.5787
d 0-63	8.92	9.19	9.48	9.30	9.22	0.1471	0.6001
d 0-84	9.13	9.42	9.74	9.48	9.44	0.1442	0.5390
d 0-96	9.18	9.43	9.79	9.56	9.49	0.1516	0.5569
PDMI, %							
d 0-21	2.21	2.23	2.30	2.25	2.25	0.0344	0.8086
d 0-42	2.17	2.22	2.28	2.21	2.22	0.0326	0.7103
d 0-63	2.13	2.16	2.24	2.16	2.17	0.0294	0.6090
d 0-84	2.12	2.14	2.22	2.12	2.15	0.0260	0.4925
d 0-96	2.10	2.14	2.21	2.11	2.14	0.0242	0.4060

MO = monensin sodium; EO = essential oil; VI = virginiamycin; MSE = Mean Standard Error;
Average daily gain (ADG); feed efficiency (FE); Dry matter intake (DMI); Dry matter intake per 100kg live weight (PDMI);
Medium, followed by lowercase letters differ significantly (Tukey test at 5%).

Sitta (2011), which obtained an increase of 8.27% of Nelore bulls diets high concentrate content and only consumed MO than those who were fed MO+VI. Already Ferreira et al. (2015), with grazing cattle with inclusion of virginiamycin, obtained an increase of 25.5% in weight gain compared to the control group (without additive). The combination of MO+VI and EO also showed no significant difference in relation to the diet with only MO, working to feed high concentrate averaging: 1.56 kg day $^{-1}$, 1.64 kg day $^{-1}$ and 1.55 kg day $^{-1}$ respectively (SILVA, 2014).

As for essential oils Meyer et al. (2009) found no difference in weight gain when compared to the MO, which was also observed by Jedlicka et al. (2009) who did not reach difference when fed heifers with only MO comparing MO+EO association (brown oil and castor oil), where MO+EO association had a decrease numerically, as in the present study (1.651 kg versus 1.569 kg).

Sitta (2011) states that the VI has a greater ability to ruminal microbiota manipulation, taking with it a better control on lactate production and a decrease in methane production, generating lower energy losses, explaining the fact that the treatments VI get better results in this study.

Feed efficiency (Table 1) there was no difference (P> 0.05) in the first four weighing averaging 0.185 kg, 0.178 kg, 0.169 kg and 0.161 kg day $^{-1}$, showing that the feed efficiency decreases with time

advance confinement. Weighing 96 days there was a difference (P <0.05) between MO+EO treatments (0.134 kg/kg DM) compared to MO+VI (0.160 kg/kg DM) and MO+VI+EO (0.159 kg/kg DM), which did not differ MO (0.145 kg/kg DM).

Silva (2014), working with rations with MO, MO+VI and EO castor bean and cashew, did not observe difference in feed efficiency between treatments with averages ranging from 0.180 kg to 0.200 kg of gain for each kg of DMI.

The DMI expressed in kg day $^{-1}$, no difference between the additive associations (P> 0.05), with averages of 8.81, 9.08, 9.22, 9.44 and 9.49 kg day^{-1} for weighing 21, 42, 63, 84 and 96 days, respectively. The results corroborate those found by Rogers et al. (1995) which did not change DM intake by including virginiamycin. Meyer et al. (2009), working with EO compared to a ration composed by MO more tylosin had a significant increase in daily dry matter intake when used essential oils, this behavior different from that found in the present study.

Lanna and Medeiros (2007) found that MO could reduce dry matter consumption without reducing energy intake. This effect is likely directly related to increased energy density, with lower methane production and higher propionate production (NRC, 1996).

Furthermore, according to Baile et al. (1979), MO supplementation leads to reduced voluntary consumption by aversion due to its low palatability. As this study had MO in all treatments, it is suggested that the small difference consumption for more when combining other additives, is due to the mechanism of action and a possible concealment of the low palatability of MO.

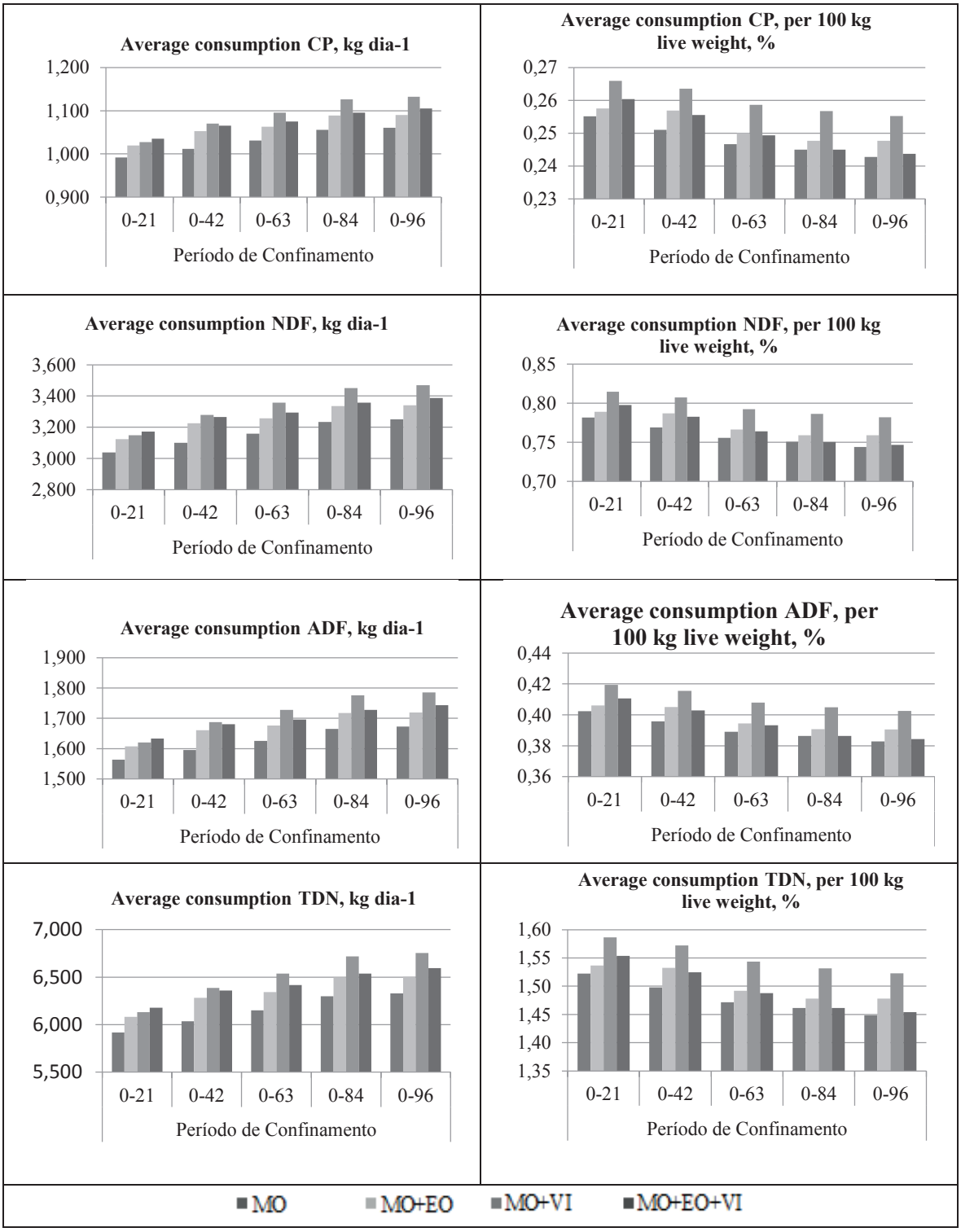
The DMI expressed as a percentage of live weight, also showed no significant difference in all weights with averages of 2.25% at 21 days, 2.22% at 42 days, 2.17% at 63 days, 2.15% after 84 days and 2.14% at the end of the experiment.

Silva (2014), with 92% feed concentrate obtained a significant difference (P = 0.02) compared to diets which had a MO+VI and only EO association (1.88% versus 2.13%) but the two combinations were not different only with MO that averaged 2.03% of consumption in relation to live weight. According to Sitta (2011), the explanation for the variation in the results related to additives for intake of dry matter is directly related to the proportion of concentration in the diet, the type of protein used and its utilization by animals and the quality of the consumed roughage.

The intakes of CP, NDF, ADF and TDN, represented in kg d $^{-1}$ ^{a}nd expressed per 100 kg of live weight, according to the evaluation periods are contained in Figure 1, the same did not show difference (P> 0.05).

Note that the intakes of CP, NDF, ADF and TDN followed the same behavior as the experiment advancement, increase in general in relation to daily consumption and decreasing in relation to the percentage of live weight. Another observed fact is that the diet without additives association had lower consumption, confirming the report that most of the literature in relation to MO where there is a decrease in consumption with no change in efficiency by increasing the availability of nutrients from the bottles. With the combination of other additives there was a small increase in consumption that helped us better performance results that the animals showed.

Figure 1. Average consumption CP, NDF, ADF and TDN in kg day $^{-1}$ and expressed per 100 kg live weight, feedlot steers, assessing the associative effect of monensin to virginiamycin and/or essential oils in food as the evaluation periods.



CP = Crude protein; NDF = neutral detergent fiber; FDA = acid detergent fiber, TDN = total digestible nutrients; MO = monensin sodium; EO = essential oil; VI = virginiamycin;
* There were no significant differences for these parameters (Tukey test at 5%).

The VI association in feed independently of the other additive (MO+VI and VI+MO+EO) generated an average carcass gain (Table 2) of 16.24% higher than the feed only with MO, generating at the end of confinement average higher TCG of 16.67 kg carcass.

Table 2. Total carcass gain and daily, carcass processing efficiency and daily carcass gain compared with average daily weight gain of steers, assessing the associative effect of monensin to virginiamycin and/or essential oils in food, as the evaluation periods.

Parameter	Experimental Feed				Average	MSE	Prob.
	MO	MO+EO	MO+VI	MO+EO+VI			
TCG, kg	98.59 b	96.68 b	114.13 a	114.49 a	105.97	2.2227	0.0222
DCG, kg	1.025 b	1.005 b	1.190 a	1.193 a	1.103	0.0237	0.0213
ECT, kg	9.01	9.38	8.29	8.03	8.68	0.1944	0.1012
DCG/ADG,%	77.72	80.13	77.28	78.44	79.12	1.6635	0.9310

MO = monensin sodium; EO = essential oil; VI = virginiamycin; MSE = Mean Standard Error;
Total carcass gain (TCG) equivalent to the period of 96 days of confinement. Average daily carcass gain (DCG) and transformation efficiency of dry matter consumed in carcass (ECT) = kg DMI / kg DCG).
Medium, followed by lowercase letters, in line, differ by 5% Tukey test.

The ECT showed no difference (P> 0.05) for all associations presented average values of 8.68 kg of DM intake for each kilogram of carcass gain. The same happened with the relationship between DCG and ADG between additives associations presenting 79.12% of the daily weight gain was earned in housing.

Silva (2014), in 120 days of confinement contrary to this work no significant difference in diets with MO compared to MO+VI and only EO, with average GCT values of 128.07 kg, thereby generating a DCG of 1.07 kg per day. In the same study to ETC and the relationship ADG/DCG as well as the present study, no difference was observed with average values of 7.75kg of CMS to make one kg of carcass and ratio of 69.62% of ADG is represented by housing gain.

The average production of manure in kg day^{-1} in natural base in dry basis and apparent digestibility (Table 3), showed no effect on different associations, with average values of 17.39 kg day –1, 2.95 kg day-1 and 69.19%, respectively. Nuñez et al. (2013) also no significant difference in the apparent digestibility when virginiamycin and ionophore included in diets of Nellore bulls. The same happened in the studies of Meyer et al. (2009) comparing that EO and ionophores, no observed difference.

The associative effect of monensin to virginiamycin and/or essential oils in the feed did not affect the quantitative characteristics of carcasses (P> 0.05) (Table 4). On the average carcass yield, carcass length, cushion thickness, arm length and arm perimeter, gave values of 55.4%, 128.9cm, 19.36cm, 39.27 cm and 41.17cm, respectively.

Table 3. Average manure production in kg day $^{-1}$ and apparent digestibility of diets for steers. assessing the associative effect of monensin to virginiamycin and/or essential oils in food.

Experimental Feed	Manure production (Kg / day MV)	Manure production (Kg DM / day)	Apparent digestibility of feed (%)
MO	17.10	2.90	69.22
MO+EO	17.58	2.91	68.69
MO+VI	17.99	2.99	70.18
MO+EO+VI	16.87	3.00	68.60
Avarege	17.39	2.95	69.19
MSE	0,64	0,10	0,50
Probability	0.93	0.97	0.68

MO = monensin sodium; EO = essential oil; VI = virginiamycin; MSE = Mean Standard Error;
Medium, followed by lowercase letters, in column, differ by 5% Tukey test.

Table 4. Carcass characteristics of feedlot finished steers evaluating the associative effect of monensin to virginiamycin and/or essential oils in food.

Parameter	Experimental Feed						
	MO	MO+EO	MO+VI	MO+EO+VI	Average	MSE	Prob.
Live weight farm. kg	518 b	519 b	539 a	545 a	530	6.2143	0.0491
Housing Income.%	55.0	55.2	55.4	56.0	55.4	0.3878	0.8169
Housing Length. cm	128.75	127.90	129.11	130.06	128.9	0.6998	0.7609
Thickness of topside. cm	19.29	18.26	19.71	20.16	19.36	0.1968	0.0592
Arm Length. cm	39.66	39.53	38.54	39.35	39.27	0.2682	0.4566
Arm Perimeter. cm	40.93	40.94	41.04	41.76	41.17	0.2749	0.6722
Fat Thickness. mm	3.77 b	4.38 a	4.50 a	4.40 a	4.26	0.1431	0.0122

MO = monensin sodium; EO = essential oil; VI = virginiamycin; MSE = Mean Standard Error;
Medium, followed by lowercase letters differ significantly (Tukey test at 5%).

The live weight of the farm was no significant difference, and animals that have associated MO+VI and MO+EO+VI, had an average of 542 kg live weight farm against 518.5 kilograms of MO+EO and only MO groups. There were also differences in factor fat thickness, where all the associations differ from the group with only MO (3.77 mm) against MO+EO (4.38mm), MO+VI (4.50mm) and MO+VI+EO (4.40 mm).

The carcass yield and final weight of confinement weight data of the present study corroborate with those found by Sitta (2011), in Nelore steers finished with MO and with MO+VI. However for the same fat thickness found no significant difference. Jedlicka et al. (2009) also found no differences for hot carcass weight and carcass yield between MO+EO association between only MO, compared to separate additives for hot carcass weight and carcass yield.

The results obtained in this study were the same as obtained in the studies of Meyer et al. (2009) in which the feed with essential oil were higher in fat finishing in housing compared to only with monensin and did not change in the quantitative characteristic of the housing with the performance and the final weight of the farm. In a study of Silva (2014), in diets with MO and MO + VI no observed difference between hot carcass weight, carcass yield and fat thickness.

The feeding behavior of the activities expressed in hours per day, ruminating, entertainment, food consumption and water consumption (Table 5) of feedlot finished steers independently of the additive

combination used, there was no difference (P> 0.05) presenting average values of 7,44 hours, 13,00 hours, 3,28 hours, 0,16 hours respectively.

In rumination parameters evaluated entertainment, food intake, water intake. The fact can be explained by the physical characteristics of the feed, which is the same, differing only the combination of additives. The feeding time and the behavior of the activities were also not changed (P> 0.05) with the addition of MO and MO + VI (SITTA, 2011).

Table 5. Animal Behaviour and cattle feedlot evaluating the associative effect of monensin virginiamycin or essential oils in food.

Activity	Experimental Feed				Average	Prob.
	MO	MO+EO	MO+VI	MO+EO+VI		
			Hours day^{-1}			
Rumination	7.33	7.30	7.65	7.50	7.44	0.9516
Idleness	13.40	13.30	12.74	12.57	13.00	0.7728
Feed intake	3.13	3.27	3.25	3.47	3.28	0.9239
Water intake	0.16	0.19	0.14	0.15	0.16	0.8881
			Number of times day^{-1}			
Alimentation	24.75	21.75	20.58	21.58	22.17	0.3080
Water intake	4.75	6.00	5.17	6.17	5.52	0.9358
Solid excretions	8.92	10.83	9.58	10.75	10.02	0.5131
Fluid excretions	5.67	6.75	6.08	7.17	6.42	0.6911

MO = monensin sodium; EO = essential oil; VI = virginiamycin;
Medium, followed by lowercase letters differ significantly (Tukey test at 5%).

Differences were not observed (P> 0.05) for power frequency parameters, water intake, liquid excreta and solid excreta, with average values of 22.17 times the feed trough, 5.52 times water cooler, 10.02 defecation and urination 6.42 per day evaluation. Silva (2014) also observed no difference in the number of daily meals when associated MO + VI and compared diets of MO and EO separately. Mariani et al. (2010) shows that animals fed monensin had higher number of meals per day, indicating that the animals parcelam intake of rapidly fermentable carbohydrates that reach the rumen. Thus, the passage rate can be decreased and the use of enhanced nutrients, reducing the intake of dry matter.

Conclusions

The use of the association MO+VI and MO+EO+VI in the doses of the present study are recommended in finishing confined steers, because they present better results in relation to animal performance, being superior in ADG, DCG and TCG. Feed efficiency, dry matter intake and nutrient intake expressed in kg day^{-1} and percentage of live weight, apparent digestibility and ingestive behavior parameters were not affected under associative effect of MO with VI or EO.

Supplementation with EO or VI resulted in greater fat thickness in the carcasses, without changing the quantitative characteristics of the carcasses. Further studies should be done between additives associations, so that we can achieve greater advances in nutrition of confined animals.

References

BAILE, C. A.; MC LAUGHLIN, C. L.; POTTER, E. L.; CHALUPA, W. Feeding behavior changes of cattle during introduction of monensin with roughage or concentrate diets. *Journal of Animal Science*, Champaign, v. 48, n. 6, p. 1501-1508, 1979.

BATISTA, S.; PRADO, G.; FREITAS, P.; PRADO, T. *Cadernos de Pós-Graduação da FAZU*, Uberaba, v. 2, 2012.

BENCHAAR, C.; CALSAMIGLIA, S.; CHAVES, A. V.; FRASER, G. R.; COLOMBATTO, D.; McALLISTER, T. A.; BEAUCHEMIN, K. A. A review of plant-derived essential oils in ruminant nutrition and production. *Animal Feed Science and Technology*, Amsterdam, v. 145, n. 1/4, p. 209-228, 2008.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. *Plano mais pecuária.* Tiragem 5000. Assessoria de Gestão Estratégica. Biblioteca Nacional de Agricultura, BINAGRI, Brasília, 2014. 34 p.

CALSAMIGLIA, S.; BUSQUET, M.; CARDOZO, P. W.; CASTILLEJOS, L.; FERRET, A. Invited review: essential oils as modifiers of rumen microbial fermentation. *Journal of Dairy Science*, New York, v. 90, n. 6, p. 2580-2595, 2007b.

CALSAMIGLIA, S.; BUSQUET, M.; CARDOZO, P. W.; CASTILLEJOS, L.; FERRET, A; FANDINO, I. The use of essential oils in ruminants as modifiers of rumen microbial fermentation. *Penn State Dairy Cattle Nutrition Workshop*, Grantville, v. 13-14, p. 87-100, 2007a.

FERREIRA, S. F.; FERNANDES, J. J. R.; PÁDUA, J. T.; BILEGO, U. O.; LIMA, M. A. S.; FRANÇA, A. F. S.; BENTO, E. A.; OLIVEIRA, L. G.; GRANDINI, D. Desempenho e metabolismo ruminal em bovinos de corte em sistema de pastejo no período seco do ano recebendo virginiamicina na dieta. *Semina: Ciências Agrárias,* Londrina, v. 36, n. 3, p. 2067-2078, 2015. Suplemento 1.

JEDLICKA, M. E.; PUREVJAV, T.; CONOVER, A. J.; HOFFMAN, M. P.; PUSILLO, G. *Effects of functional oils and monensin alone or in combination on feedlot cattle growth and carcass composition.* Ames: Iowa State University Animal Industry Report, A. S. Leaflet R2423, 2009. 4 p. Available at: <http://http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1463&context=ans_air>. Accessed at: 31 may 2016.

LANNA, D. P. D.; MEDEIROS, S. R. Uso de aditivos na bovinocultura de corte. In: SANTOS, F. A. P.; MOURA, J. C.; FARIA, V. P. *Requisitos de qualidade na bovinocultura de corte.* Piracicaba: FEALQ, 2007. cap. 15, p. 297-324.

LOPES, M. A.; MAGALHÃES, G. P. Análise da rentabilidade da terminação de bovinos de corte em condições de confinamento: um estudo de caso. *Arquivos Brasileiros de Medicina Veterinária e Zootecnia,* Belo Horizonte, v. 57, n. 3, p. 374-379, 2005.

MARIANI, T. M.; PACHECO, R. D. L.; ARRIGONI, M. D. B.; MARTINS, C. L.; BALDIN, S. R.; SARTI, L. M. N.; BARDUCCI, R. S.; MARIANI, T. M.; RONCHESEL, J. R.; PARRA, F. S.; TOMAZELLA, D.; BASTOS, J. P. S. T.; OGAWA, E. S.; MILLEN, D. D. Effects of feeding polyclonal antibody preparations against lactate–producing rumen bacteria or monensin on feeding behavior of feedlot cattle. *Journal of Dairy Science,* New York, v. 93, p. 709-709, 2010.

MEYER, N. F.; ERICKSON, G. E.; KLOPFENSTEIN, T. J.; GREENQUIST, M. A.; LUEBBE, M. K.; WILLIANS, P.; ENGSTROM, M. A. Effect of essential oils, Tylosin and monensin on finishing steer performance, carcass characteristics, liver abscesses, ruminal fermentation and digestibility. *Journal of Animal Science,* Champaign, v. 87, n. 7, p. 2346-2354, 2009.

MÜLLER, L. *Normas para avaliação de carcaças e concurso de carcaça de novilhos.* 2. ed. Santa Maria: Universidade Federal de Santa Maria, 1987. 31 p.

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

NATIONAL RESEARCH CONCIL – NRC. Nutrient requirement of beef cattle. 7th ed. Washington: National Academy Press, 1996. 242 p.

NUÑEZ, A. J. C.; CAETANO, M.; BERNDT, A.; DEMARCHI, J. J. A. A.; LEME, P. R.; LANNA, D. P. D. Combined use of ionophore and virginiamycin for finishing Nellore steers fed high concentrate diets. *Scientia Agricola*, Piracicaba, v. 70, n. 4, p. 229-236, 2013.

PAGE, S. W. *The role of enteric antibiotics in livestock production.* Camberra: Avcare Limited, 2003. 337 p.

RANGEL, A. H. N.; LEONEL, F. P.; SIMPLÍCIO, A. A.; MENDONÇA, A. F. Utilização de ionóforos na produção de ruminantes. *Revista de Biologia e Ciências da Terra*, João Pessoa, v. 8, n. 1, p. 264-273, 2008.

ROGERS, J. A.; BRANINE, M. E.; MILLER, C. R.; WRAY, M. I.; BARTLE, S. J.; PRESTON, R. L.; BECHTOL, D. T. Effects of dietary virginiamycin on performance and liver abscess incidence in feedlot cattle. *Journal of Animal Science*, Champaign, v. 73, n. 1, p. 9-20, 1995.

SILVA, A. P. S. *Efeito da monensina, da virginiamicina e dos* óleos *funcionais de mamona e caju em bovinos Nelore submetidos a mudança abrupta para dietas com elevado teor de concentrado.* 2014. Dissertação (Mestrado em Qualidade e produtividade Animal) – Faculdade de Zootecnia e Engenharia de Alimentos. Universidade de São Paulo, Pirassununga.

SITTA, C. *Aditivos (ionóforos, antibióticos não ionóforos e probióticos) em dietas com alto teores de concentrado para tourinhos da raça Nelore em terminação.* 2011. Dissertação (Mestrado em Medicina Veterinária) – Escola Superior de Agricultura Luiz Queiroz, Universidade de São Paulo, Piracicaba.

STATISTICAL ANALYSIS SYSTEM INSTITUTE – SAS Institute. SAS/STAT user's Guide: statistics, version 6. 4. ed. Cary: SAS Institute, 1993. v. 2, 943 p.

VAN SOEST, P. J. *Nutritional ecology of the ruminant.* 2th ed. Ithaca: Cornell University Press, 1994. 476 p.

ZANINE, A. M.; OLIVEIRA, J. S.; SANTOS, E. M. Importância, uso, mecanismo de ação e retorno econômico dos ionórofos na nutrição de ruminantes. *Revista Científica Eletrônica de Medicina Veterinária*, Garça, v. 3, n. 6, p. 45-56, 2006.