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Whole soy lecithin on productivity and carcass quality of feedlot cattle

Lecitina integral de soja na produtividade e qualidade de carcaças de bovinos confinados

Mikael Neumann[1], Elisa Emanuela Bremm[1], André Martins de Souza*[2], Paulo Eduardo Piemontez de Oliveira[1], Fernando de Souza Sidor[1], Daniel Corrêa Plodoviski[1], Bruna Maria Hoffmann Karas[1], Marcia Regina Skorei[3], André Ostrensky[4]

[1] Universidade Estadual do Centro-Oeste (UNICENTRO), Guarapuava, Paraná, Brasil
[2] Universidade Estadual de Londrina (UEL), Londrina, Paraná, Brasil
[3] Sanex Comércio e Indústria Veterinária, Curitiba, Paraná, Brasil
[4] Pontifícia Universidade Católica do Paraná (PUCPR), Curitiba, Paraná, Brasil
*corresponding author: andrems_92@hotmail.com

Abstract: The present study aimed to evaluate the effect of different levels of whole soy lecithin on the apparent digestibility of the diet, ingestive behavior, productive performance, and carcass characteristics of feedlot-finished beef cattle. This was a completely randomized experimental design involving three treatments: Control diet; Diet with whole soy lecithin (10 g animal^{-1} day^{-1}); and Diet with whole soy lecithin (20 g animal^{-1} day^{-1}), with five replications. The diets were formulated and constituted of 33% corn silage and 67% concentrate, on a dry matter basis. Thirty non-castrated ½ Angus × ½ Nellore steers, with an average age of 14 months and average initial body weight of 432 kg, were used in the experiment. The dietary inclusion of whole soy lecithin improved the digestibility of ether extract and neutral detergent fiber but did not influence ingestive behavior. Supplementation with 10 g animal^{-1} day^{-1} of whole soy lecithin resulted in higher average weight gain (1.707 kg day^{-1}) followed by non-supplemented animals (1.645 kg day^{-1}) and those supplemented with whole soy lecithin at 20 g animal^{-1} day^{-1} (1.587 kg day^{-1}). Carcass fatness was not altered with the supplementation of whole soy lecithin. The supply of whole soy lecithin improved the use of the ether extract and fiber fraction of the diet and resulted in the highest average weight gain. The level of 10 g animal^{-1} day^{-1} provided the best responses.

Keywords: emulsifier; ingestive behavior; feed conversion; nutrient digestibility; productive performance

Resumo: O presente estudo teve por objetivo avaliar o efeito de diferentes doses de lecitina integral de soja na digestibilidade aparente da dieta, comportamento ingestivo, desempenho produtivo, e nas características de carcaça de bovinos de corte terminados em confinamento. O delineamento experimental foi inteiramente casualizado, constituído de três tratamentos, sendo: Ração controle; Ração com lecitina integral de soja (10 g animal^{-1} dia^{-1}); e Ração com lecitina integral de soja (20 g

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animal^{-1} dia^{-1}), com cinco repetições. As rações, em base na matéria seca, foram formuladas e constituídas por 33% de silagem milho e 67% de concentrado. Foram utilizados 30 novilhos não castrados, ½ sangue Angus Nelore, com idade média de 14 meses e peso vivo médio inicial de 432,3 kg. A digesibilidade do extrato etéreo e da fibra em detergente neutro foi melhorada com a inclusão de lecitina integral de soja, já o comportamento ingestivo não foi alterado. A suplementação com 10 g animal^{-1} dia^{-1} de lecitina integral de soja proporcionou maior média para ganho de peso (1,707 kg dia^{-1}) seguido dos animais não suplementados (1,645 kg dia^{-1}) e suplementados com lecitina integral de soja na dose de 20 g animal^{-1} dia^{-1} (1,587 kg dia^{-1}) . Em relação ao acabamento das carcaças, este não foi alterado com a suplementação de lecitina integral de soja. O uso de lecitina integral de soja melhorou o aproveitamento da fração etérea e fibrosa da ração, e garantiu a maior média para ganho de peso, sendo a dose de 10 g animal^{-1} dia^{-1} com melhores respostas.

Palavras-chave: comportamento ingestivo; conversão alimentar; desempenho produtivo; digestibilidade de nutrientes; emulsificante.

1. Introduction

The intensification of livestock farming today is essential to ensure profitability to the segment, which can be guaranteed by better production performance, better feed efficiency, and better-finished carcasses, which can add value at the time of sale. One way to achieve these objectives is to use diets with higher energy density in the finishing phase[1]. The dietary energy content can be increased by including non-fiber carbohydrates or lipids, which contain 2.25 times more energy than carbohydrates. However, for physiological reasons, there are limitations to its inclusion, which should not be higher than 7.0% as it is toxic to ruminal microorganisms and reduces fiber digestion[2].

However, the supply of such diets requires additives to enhance energy utilization, short-chain fatty acid synthesis, as well as animal production efficiency and growth rates[3]. An alternative to obtain these results is to include soy lecithin, a product composed of phosphatidyl choline, phosphatidyl ethanolamine, phosphatidyl inositol, glycolipids, triglycerides, and carbohydrates[4]. Soy lecithin can be used to feed ruminants as an emulsifier since it promotes the incorporation of fatty acids and increases their absorption in the small intestine due to its ability to pass through the rumen and also increase the digestibility of fats. As such, it enables the use of higher levels of fat in the diet without damaging ruminal fermentation[5, 6, 7].

Emulsifier supplementation at increasing levels increases the digestibility and absorption of total fatty acids and fatty acids with 16 and 18 carbon molecules in lactating cows, in addition to increasing milk fat content and the concentration of plasma unsaturated fatty acids[8]. Chen et al.[9] evaluated Simmental steers and observed that supplementation with soy lecithin resulted in higher weight gain compared with absence of supplementation.

Therefore, the present research evaluated the effect of different levels of whole soy lecithin on the productive performance, ingestive behavior, apparent digestibility of the diet, and carcass characteristics of feedlot-finished cattle.

2. Material and methods

The experiment was carried out in the Laboratory of Food Analysis and Nutrition of Ruminants and the teaching, research, and extension unit in Beef Cattle – Feedlot of the Animal Production Center (NUPRAN) of the Master's Program in Veterinary Sciences, Agricultural Sciences and Environmental Sector at the State University of the Center-West (CEDETEG/UNICENTRO), located in Guarapuava, state of Paraná, Brazil. The experimental procedures were previously submitted for consideration by the Animal Experimentation Research Ethics Committee (CEUA/UNICENTRO) and approved according to letter 051/2021 of 03/12/2021. According to Köppen-Geiger's classification, the climate of Guarapuava region is humid subtropical mesothermal (Cfb), with no dry season, with cool summers and moderate winters. The region is situated at an altitude of approximately 1,100 m, with an average annual precipitation of 1,944 mm and an average annual minimum temperature of 12.7 ºC.

Thirty non-castrated ½ Angus × ½ Nellore steers, with an average initial weight of 432.3 kg ± 6.0 kg and an average initial age of 14 ± 1.5 months, were used. This was a completely randomized experimental design consisting of three treatments: Control diet; Diet with whole soy lecithin (10 g animal^{-1} day^{-1}); and Diet with whole soy lecithin (20 g animal^{-1} day^{-1}). Five replications were used per treatment. Each pen, containing two animals, was considered a replication. Whole soy lecithin was supplied using the product POWERBOV LC® from the company Sanex Comércio e Indústria Veterinária Ltd., a product whose main component is refined soy lecithin at a concentration of 650 g kg^{-1}, which also contains emulsification precursors, palm kernel oil, glycine, taurine, and silica.

The experimental period was 110 days, consisting 16 days of adaptation to the diets and facilities and 94 evaluation days, divided into two periods of 28 days and one period of 38 days. The facilities consisted of 15 feedlot pens, 15 m^2 each (2.5 m x 6.0 m), with concrete feeders 2.30 m long, 0.60 m wide, and 0.35 m high, and metal drinkers with automatic water replacement. Animals were distributed into the experimental units according to body weight (BW), ribeye area (RA), marbling, and rump fat thickness (RFT) measured using ultrasound (Aloka® SSD- 500 Vet) consisting of an echo camera coupled to a 17 cm and 3.5 MHz probe. These measurements were taken on the last day of the adaptation period, that is, the beginning of the evaluation period.

Animals were fed *ad libitum* twice a day, at 06h00 and 17h30. Voluntary feed intake was recorded daily by weighing the amount offered and the leftovers from the previous day. Intake was adjusted daily to allow for 5.0% leftovers of the total supplied on a dry matter basis. Diets consisted of 33% corn silage and 67% concentrate and were provided as total mixed ration (TMR). To prepare the concentrate, the following ingredients were used: 16.0% wheat bran, 5.1% soybean meal, 14.0% soybean hulls, 5.0% barley radicle, 23.0% corn germ, 5.0% barley grains, 25.0% ground corn grain, 2.8% degummed soybean oil, 0.6% sodium chloride, 2.0% calcitic limestone, 0.5% common salt, 0.5% livestock urea, and 0.5% vitamin-mineral premix*. Before being given to the animals, the emulsifier was weighed to its respective doses, diluted in 200 g of vehicle (ground corn), and supplied at the time of eating as a top dressing, mixing it with the other diet components. For the control group, only the vehicle was provided.

Samples of corn silage and concentrate were collected weekly and dried in a forced-air oven at 50 °C for 72 h to determine the partial dry matter. The pre-dried samples were ground in a Wiley mill through a 1.0-mm screen and sent for chemical analysis. The ground samples were analyzed for dry matter (DM), mineral matter (MM), ether extract (EE), and crude protein (CP), according to AOAC[(10)]. To determine P and Ca levels, analyses were carried out according to the methodology described by Tedesco et al.[(11)]. Neutral detergent fiber (NDF) was obtained according to Soest et al.[(12)] using thermostable α-amylase, whereas acid detergent fiber (ADF) was determined as per Goering and Van Soest[(13)].

For lignin determination, sulfuric acid was used at a concentration of 72%. Non-fiber carbohydrates (NFC) were estimated using the formula NFC = 100 – (CP + NDFcp + EE + MM), where NDFap corresponds to NDF corrected for ash and protein. Starch concentration in the diet was determined by the enzymatic method proposed by Knudsen et al.[(14)]. Total digestible nutrient (TDN) contents were calculated according to equations by Weiss et al.[(15)].

Table 1 lists the chemical composition of the corn silage and concentrate used to feed the animals and the mean values of the experimental diet, on a total dry matter basis.

Table 1. Chemical composition of feedstuffs and experimental diet, with different levels of whole soy lecithin, given to feedlot-finished non-castrated ½ Angus × ½ Nellore steers

Parameter	Corn silage	Concentrate*	Experimental diet
Dry matter, % as fed	34.34	90.04	71.66
Mineral matter, % DM	3.88	6.74	5.80
Crude protein, % DM	7.02	14.45	12.00
Ether extract, % DM	2.77	6.05	4.97
Neutral detergent fiber, % DM	45.41	23.36	30.64
Acid detergent fiber, % DM	28.85	11.78	17.41
Lignin, % DM	4.86	1.72	2.76
Non-fiber carbohydrates, % DM	40.92	49.40	46.60
Starch, % DM	33.51	29.88	31.08
Calcium, % DM	0.28	0.92	0.71
Phosphorus, % DM	0.17	0.40	0.32
Total digestible nutrients, % DM	67.65	75.89	73.17

**Guaranteed levels of the premix per kg of concentrate - vit. A: 16,000 IU, vit. D3: 2,000 IU, vit. E: 25 IU, S: 0.36 g, Mg: 0.74 g, Na: 3.6 g, Co: 0.52 mg, Cu: 22.01 mg, F: 18.00 mg, I: 1.07 mg, Mn: 72.80 mg, Se: 0.64 mg, Zn: 95.20 mg, and sodium monensin: 40 mg.*
DM: dry matter.

For the evaluation of the apparent digestibility of DM, NDF, and EE, the total feces produced by the animals in each pen were collected at intervals of 6 h, for two days. After total collection, the feces produced were weighed and a homogeneous sample of 500 g was stored under freezing. Simultaneously, diet samples were taken on both days and stored under freezing. After the end of the evaluation, samples were thawed, homogenized to form a composite sample per pen and treatment, and sent for determination of DM, NDF, and EE using the same methodologies adopted for silage and concentrate samples. Fecal pH was measured according to Cherney and Cherney[16]. The digestibility of DM, NDF, and EE of the experimental diets was determined by the following equation: D (%) = [(g of nutrient ingested – g of nutrient excreted) ÷ g of nutrient ingested] x 100.

During the experimental period, feces from each pen were analyzed daily by visual observation and using scores ranging from 1 to 6 points, based on the methodology adapted from Looper et al.[17] and Ferreira et al.[18]: 1 = liquid feces, not very consistent; 2 = liquid feces, not very consistent, with small piles of up to 2.5 cm; 3 = intermediate feces with concentric ring and 3.0 to 4.0 cm liquid pile; 4 = slightly liquid stools with concentric rings and a pile of more than 5.0 cm; 5 = dry feces, concentric rings, and pile of more than 5.0 cm; 6 = hardened or dried feces.

Ingestive behavior was analyzed over a continuous period of 48 h, in the middle of the second feedlot period (corresponding to the 42nd, 43rd, and 44th evaluation days), starting at 12h00 on the first day and ending at 12h00 on the third day of evaluation, following the methodology by Ribas et al.[19].

Observations were carried out by nine observers per shift, for 48 h, who took turns every 6 h, with readings taken at regular intervals of 3.0 min. Behavior was represented by activities of idling, ruminating, drinking, and feeding, expressed in hours per day. Following the same methodology, the frequency of feeding, drinking, urinating, and defecating activities was expressed in bouts per day. During night observation, the environment was kept under artificial lighting, a condition that was maintained since the animals arrived at the experimental unit.

Performance was analyzed on the 28th, 56th, and 94th experimental days to evaluate whether or not the responses to supplementation with whole soy lecithin were beneficial only in the initial, intermediate, and final phases or whether they would maintain the same pattern from the beginning to end of the experimental period concerning the variables measured. These evaluations were carried out after fasting from solids for ten hours for individual weighing. The variables evaluated were body weight (BW), dry matter intake expressed in kg animal^{-1} day^{-1} (DMI), dry matter intake expressed as a percentage of body weight (DMI, % BW), average daily weight gain (ADG, kg day^{-1}), and feed conversion (FC, kg kg^{-1}).

On the last day of the experimental period, evaluations of RA, marbling, ratio, subcutaneous fat thickness over the *Longissimus dorsi* muscle, and RFT were carried out using an ultrasound of the company Designer Genes Technology, employing the "BIA/DGT" software. Brazil". Measurements were taken at the 12th and 13th ribs, transversely to the *Longissimus dorsi* muscle, following the recommendations by Herring et al.[20]. Marbling was assessed through the existence of fat deposits between the muscle fibers in the *Longissimus dorsi* and scored using increasing indices ranging from 1.0 (non-existent) to 5.0 (excessive) points, adapted from the system proposed by Müller[21]. Due to the difference in ultrasound measurements at the end and beginning of the experimental period, it was possible to obtain gains in RA, marbling, ratio, and subcutaneous fat thickness during the finishing phase.

At the end of the feedlot period, animals were fasted for solids for ten hours, weighed (farm weight), and shipped to the slaughterhouse. The carcass length, arm length, arm perimeter, and round thickness were measured on the carcasses using a compass, according to Müller[21]. Following Müller's methodologies[21], fat thickness measurements were also obtained in the forequarter (scapular region), ribs (rib region), and hindquarter (upper region of the hindquarter), using a digital caliper. At slaughter, the non-carcass components called vital organs (heart, liver, lungs, and kidneys) were also weighed.

Data relating to animal performance and dry matter intake, apparent digestibility, and carcass characterization were tested by ANOVA, with subsequent comparison of means by Tukey test at a 5.0% level of significance, using the GLM procedure from SAS statistical software[22]. Data relating to ingestive behavior were tested by ANOVA, with subsequent comparison of means by Tukey's test at a 5.0% level of significance, using the PROC MIXED procedure of SAS statistical software[22].

The statistical model used was: $Yi = \mu + Ti + Ei$, where: Yi = response criterion; μ = overall mean common to all observations (constant); Ti = effect of treatment i; and Ei = random error inherent to all observations.

3. Results and discussion

As can be seen in Table 2, fecal output (kg day^{-1}), both on dry-matter and as-fed bases, dry matter content of feces, apparent digestibility of DM, and feces pH did not change (P>0.05) with the inclusion of whole soy lecithin in the feed.

Table 2. **Fecal output [as-fed (FOAF) and dry-matter (FODM) bases], fecal DM content, apparent digestibility of DM, EE, and NDF, fecal score, and feces pH of feedlot finished steers receiving diets with different levels of whole soy lecithin**

Parameter	Experimental diet			Mean	SEM	Prob.
	Control 0 g day^{-1}	Lecithin 10 g day^{-1}	Lecithin 20 g day^{-1}			
FO_{AF}, kg day^{-1}	15.31	14.37	14.57	14.75	0.912	0.7478
Fecal DM, %	20.65	19.73	20.20	20.19	0.420	0.3370
FO_{DM}, kg day^{-1}	3.16	2.84	2.94	2.98	0.198	0.5249
AD_{DM}, %	71.22	72.45	71.41	71.79	1.589	0.8619
AD_{EE}, %	89.19 b	91.69 a	91.21 a	90.70	0.483	0.0072
AD_{NDF}, %	39.04 b	43.35 a	41.17 ab	41.19	3.089	0.0260
Fecal score	3.03	2.87	2.98	2.96	0.082	0.4563
Feces pH	7.66	7.65	7.40	7.53	0.105	0.2739

a, b Means in the same row, followed by different lowercase letters, are significantly different from each other by Tukey's test at 5.0%.

SEM: Standard error of the mean.

Ether extract digestibility was higher (P<0.05) with supplementation of whole soy lecithin at 10 g day^{-1} and 20 g day^{-1} (91.69% and 91.21%, respectively), compared to the control diet (89.19%). On the other hand, NDF digestibility showed a higher mean value for supplementation at 10 g day^{-1} (43.35%) which was higher than that obtained with the control diet (39.04%) but did not differ from that achieved with supplementation at 20 g day^{-1} (41.17%).

The increased digestibility of ether extract obtained here can be justified by higher ruminal biohydrogenation of this component. Phospholipase A converts lecithin to lysolecithin, which is responsible for the emulsification of lipids, making them more available for rumen biohydrogenation and subsequent digestion(23, 24, 25).

Higher values of NDF were found with supplementation of whole soy lecithin compared to no supplementation, suggesting that it is the effect of a higher energy supply and better use of the nitrogen contained in the feed. When the feed protein enters the rumen, a portion is degraded and produces ammonia-N; according to Sniffen et al.(26), when used as a substrate by ruminal microorganisms, it contributes to the higher development of bacterial flora, resulting in higher digestibility of the fiber portions of the feed.

When evaluating different levels of soy lecithin in the diet for Simmental steers, Chen et al.(9) observed that the presence of the additive in the feed increased the energy supply available to ruminal microorganisms and reduced the concentrations of ammonia-N in the rumen compared to non-supplemented animals. The same authors report that when energy and protein are not limiting factors for microbial development, their action in the fermentation process is maximized.

Despite the improvements in the digestibility of EE and NDF of the diets (Table 2), the activities of feeding, drinking, ruminating, and idling expressed in hours per day were not changed (P>0.05) with the supplementation of different levels of whole soy lecithin (Table 3). Following this trend, the frequency of feeding, drinking, defecating, and urinating, expressed in bouts day^{-1}, were not changed.

Table 3. Ingestive behavior and frequency of activities carried out by feedlot-finished steers receiving diets with different levels of whole soy lecithin

Parameter	Experimental diet			Mean	SEM	Prob.
	Control	Lecithin 10 g day^{-1}	Lecithin 20 g day^{-1}			
Hours per day						
Feeding	2.94	2.62	2.70	2.75	0.197	0.5011
Drinking	0.41	0.34	0.30	0.35	0.065	0.5344
Ruminating	5.55	5.62	5.40	5.52	0.507	0.9430
Idling	15.14	15.44	15.63	15.40	0.499	0.7869
Bouts per day						
Feeding	19.2	19.6	20.2	19.7	1.371	0.8759
Drinking	9.2	8.8	8.2	8.7	0.987	0.7771
Defecating	10.8	10.4	8.6	9.9	1.104	0.3709
Urinating	6.8	5.8	6.4	6.3	1.039	0.6843

[a, b] Means in the same row, followed by different lowercase letters, are significantly different from each other by Tukey's test at 5.0%.

SEM: Standard error of the mean.

The lack of differences in ingestive behavior is related to the similar physical and chemical composition of the diets across treatments. According to Van Soest[27], this is the main factor in determining behavioral changes in ruminants. At the end of the feedlot period, animals supplemented with 10 g day^{-1} of whole soy lecithin displayed the highest mean values for weight gain (1.707 kg day^{-1}) compared to those supplemented with 20 g day^{-1} of whole soy lecithin (1.587 kg day^{-1}), but did not differ from animals fed the control diet (1.645 kg day^{-1}) (Table 4).

Table 4. **Average daily weight gain (ADG), dry matter intake (DMI) expressed in kg day^{-1} and per 100 kg of body weight, and feed conversion of feedlot-finished steers receiving diets with different levels of whole soy lecithin**

Parameter	Experimental diet			Mean	SEM	Prob.
	Control	Lecithin 10 g day^{-1}	Lecithin 20 g day^{-1}			
ADG, kg day^{-1}						
0 to 94 days	1.645 ab	1.707 a	1.587 b	1.646	0.072	0.0321
DMI, kg day^{-1}						
0 to 94 days	10.85	9.90	10.13	10.29	0.361	0.2137
DMI, % body weight						
0 to 94 days	2.15	1.98	2.03	2.05	0.052	0.1289
Feed conversion						
0 to 94 days	6.79	5.89	6.55	6.39	0.223	0.0540

[a, b] Means in the same row, followed by different lowercase letters, are significantly different from each other by Tukey's test at 5.0%.
SEM: Standard error of the mean.

Chen et al.[9] reported that the lower concentration of ammonia-N in the rumen of animals supplemented with soy lecithin resulted in better weight gain, as this compound was better utilized by microorganisms as a source of substrate, and enhanced the development of bacterial flora and diet digestibility. An efficient microbial development ensures that the nutrients in the feed are more efficiently utilized by the animals[28]. Average daily gain is directly related to the digestibility of the feed components[29], and the results obtained here indicate that the level of 10 g day^{-1} was responsible for the best synergy between biohydrogenation, digestibility, and nutrient utilization by the animals.

As for the obtained carcass data (Table 5), steers supplemented with whole soy lecithin at 10 g day^{-1} and those fed the control diet showed higher body weight at slaughter (591. 6 kg and 588.1 kg, respectively) than animals supplemented with 20 g day^{-1} of whole soy lecithin. The higher slaughter weight reflects the higher mean ADG value of these animals (Table 4).

Table 5. Carcass traits of feedlot-finished steers receiving diets with different levels of whole soy lecithin

Parameter	Experimental diet Control	Lecithin 10 g day^{-1}	Lecithin 20 g day^{-1}	Mean	SEM	*Prob.*
Initial body weight (kg)	432.9	432.3	431.7	432.3	5.104	0.9863
Slaughter weight (kg)	588.1 a	591.6 a	578.0 b	585.9	8.332	0.0414
Hot carcass weight (kg)	324.3	327.6	323.6	325.1	3.838	0.9864
Carcass yield (%)	55.44	55.42	55.83	55.56	0.313	0.5869
Fat thickness (mm)						
Longissimus dorsi	5.6	5.9	5.7	5.7	0.152	0.4096
Forequarter	7.1	7.2	7.1	7.1	0.332	0.9707
Ribs	5.3	5.7	5.1	5.4	0.470	0.6662
Hindquarter	4.6	5.0	4.5	4.7	0.202	0.2401
Quantitative traits (cm)						
Carcass length	142.7	142.1	142.0	142.3	1.686	0.9514
Round thickness	25.2	25.3	25.0	25.2	0.565	0.9301
Arm length	38.8	39.4	39.2	39.1	0.388	0.5642
Arm circumference	50.0	49.4	49.9	49.8	1.187	0.9300
Vital organs (% BW)						
Heart	0.35	0.35	0.37	0.36	0.007	0.1561
Liver	1.21	1.20	1.18	1.20	0.030	0.7068
Lungs	1.10	1.18	1.08	1.11	0.033	0.1565
Kidneys	0.23	0.24	0.23	0.23	0.018	0.9041

Means in the same row, followed by different lowercase letters, are significantly different from each other by Tukey's test at 5.0%.
SEM: Standard error of the mean.

Subcutaneous fat over the *Longissimus dorsi*, forequarter, ribs, and hindquarter did not differ (P>0.05) between the inclusion or not of whole soy lecithin. However, the animals in both treatments had subcutaneous fat thickness within the desired range, which is at least 3 mm, so that the carcass is protected during cooling, and the oxidation of myoglobin is slowed down and does not generate changes in meat quality until its commercialization [30, 31].

Carcass yield, carcass length, round thickness, arm length, and arm perimeter also did not differ (P>0.05), with mean values of 325.1 kg, 55.56%, 142.3 cm, 25.2 cm, 39.1 cm, and 49.8 cm, respectively. These parameters are more associated with the genetic pattern, breed, age of the animals, and whether or not they are castrated than with the diet [32].

Concerning the weight of vital organs, expressed as % body weight, there was no significant difference (P>0.05) between treatments. This is positive as it indicates that the animals did not suffer from any metabolic injury that could promote changes in the organs. Table 6 lists carcass ultrasound data, which showed no significant difference (P>0.05) between the inclusion or not of whole soy lecithin, both at slaughter and for the gain during the feedlot period.

Table 6. Ribeye area (RA), ratio, marbling, subcutaneous fat thickness (SFT), and rump fat thickness (RFT) values at slaughter and gain during the feedlot period of feedlot finished steers receiving diets with different levels of whole soybean lecithin

Parameter*	Experimental diet			Mean	SEM	Prob.
	Control	Lecithin 10 g day^{-1}	Lecithin 20 g day^{-1}			
At slaughter						
RA, cm^2	84.12	84.63	83.85	84.20	1.905	0.9570
Ratio	0.57	0.51	0.51	0.53	0.038	0.4765
Marbling, points	2.98	3.26	2.99	3.07	0.147	0.3500
SFT, mm	7.89	8.15	7.88	7.98	0.445	0.8938
RFT, mm	10.46	11.12	12.31	11.30	1.050	0.4824
Gain in the finishing period						
RA, cm^2	11.53	11.74	12.53	11.93	1.511	0.9596
Ratio	0.02	0.02	0.04	0.03	0.003	0.5263
Marbling, points	0.32	0.58	0.64	0.51	0.062	0.3438
SFT, mm	3.10	3.68	2.98	3.25	0.420	0.4766
RFT, mm	4.17	5.30	5.78	5.08	0.647	0.4459

Means in the same row, followed by different lowercase letters, are significantly different from each other by Tukey's test at 5.0%.
SEM: Standard error of the mean.

These findings demonstrate that the supply of whole soy lecithin exerted a more pronounced influence on the digestibility and utilization of some dietary nutrients, leading to weight gain, as compared to its impact on the deposition of subcutaneous tissue, marbling, and meat cut yields.

4. Conclusion

The supply of whole soy lecithin improved the digestibility of the ether extract and fiber fractions of the diet. The whole soy lecithin inclusion level of 10 g animal^{-1} day^{-1} was more effective than the level of 20 g animal^{-1} day^{-1}, as it led to a higher average daily gain and a higher slaughter weight.

Conflict of interests

The authors declare no conflict of interest

Author contributions

Conceptualization: M. Neumann. *Data curation*: M. Neumann. *Formal Analysis*: M. Neumann. *Funding acquisition*: M. Neumann and M. R. Skorei. *Project administration*: M. Neumann. *Methodology*: M. Neumann, M. R. Skorei and A. Ostrensky. *Supervision:* E. E. Bremm, M. Neumann and A. M. Souza. *Visualization*: E. E. Bremm and A. M. Souza. *Investigation*: E. E. Bremm, A. M. Souza, P. E. P. Oliveira, F. S. Sidor, D. C. Plodoviski and B. M. H. Karas. *Writing (original draft)*: E. E. Bremm. *Writing (review & editing)*: M. Neumann, A. M. Souza, M. R. Skorei, A. Ostrensky.

References

1- Abreu JADC, Neumann M, Paris W, Souza AM, Vigne GLD, Almeida ER, Cristo FB, Sidor FS. Combination of carbohydrases and essential oils improve dietary performance of feedlot steers on a high-energy diet. Semina: Ciências Agrárias. 2022;43(2):523-540. https://doi.org/10.5433/1679-0359.2022v43n2p523

2- Pitta D, Indugu N, Vecchiarelli B, Rico DE, Harvatine KJ. Alterations in ruminal bacterial populations at induction and recovery from diet-induced milk fat depression in dairy cows. Journal of Dairy Science. 2018;101(1):295-309. https://doi.org/10.3168/jds.2016-12514

3- Min BR, Solaiman S, Waldrip HM, Parker D, Todd RW, Brauer D. Dietary mitigation of enteric methane emissions from ruminants: A review of plant tannin mitigation options. Animal Nutrition. 2020;6(3):231-246. https://doi.org/10.1016/j.aninu.2020.05.002

4- Li XZ, Park BK, Hong BC, Ahn JS, Shin JS. Effect of soy lecithin on total cholesterol content, fatty acid composition and carcass characteristics in the longissimus dorsi of Hanwoo steers (Korean native cattle). Animal Science Journal. 2017;88(6):847-853. https://doi.org/10.1111/asj.12660

5- Overland M, Tokach MD, Cornelius SG, Pettigrew JE, Rust JW. Lecithin in swine diets: I. Weanilling pigs. Journal of Animal Science. 1993;71(5):1187-1193. doi: https://doi.org/10.2527/1993.7151187x

6- Abel-Caines SF, Grant RJ, Morrison M. Effect of soybean hulls, soy lecithin, and soapstock mixtures on ruminal fermentation and milk composition in dairy cows. Journal of Dairy Science. 1998;81(sn):462-470.

7- Wojtas E, Zachwieja A, Piksa E, Zielak-Steciwko AE, Szumny A, Jarosz B. Effect of soy lecithin supplementation in beef cows before calving on colostrum composition and serum total protein and immunoglobulin G concentrations in calves. Animals. 2020;10(5):765-775. https://doi.org/10.3390/ani10050765

8- Souza J, Westerrn M, Lock AL. Abomasal infusion of an exogenous emulsifier improves fatty acid digestibility and milk fat yield of lactating dairy cows. Journal of Dairy Science. 2020;103(7):6167-6177. https://doi.org/10.3168/jds.2020-18239

9- Chen GJ, Zhang R, Wu JH, Shang YS, Li XD, Qiong M, Xiong XQ. Effects of soybean lecithin supplementation on growth performance, serum metabolites, ruminal fermentation and microbial flora of beef steers. Livestock Science. 2020;240(sn):104-121. https://doi.org/10.1016/j.livsci.2020.104121

10- AOAC. Association of Official Analytical Chemists - A.O.A.C. Official methods of analysis. 16.ed Washington, D.C. 1995.

11- Tedesco MJ, Gianello C, Bissani CA, Bohnen H, Volhweiss SJ. Análises de solo, plantas e outros materiais. 2 ed. Porto Alegre: Universidade Federal do Rio Grande do Sul; 1995. 173p.

12- Van Soest PJ, Robertson JB, Lewis BA. Carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science. 1991;74(10):3583-3597. doi: http://doi.org/10.3168/jds.S0022-0302(91)78551-2

13- Goering HK, Van Soest PJ. Forage fiber analyses: (apparatus, reagents, procedures, and some applications). Washington, D.C.: Agricultural Research Service, U.S. Dept. of Agriculture; 1970. https://handle.nal.usda.gov/10113/CAT87209099

14- Knudsen KEB, Johansen HN, Glitso V. Methods for analysis of dietary fibre - advantage and limitations. Journal of Animal and Feed Sciences. 1997;6(2):185-206. https://doi.org/10.22358/jafs/69515/1997

15- Weiss WP, Conrad HR, Pierre NR. Atheoretically-based model for predicting total digestible nutrient values of forages and concentrates. Animal Feed Science and Technology. 1992;39(1-2):95-110. doi: http://doi.org/10.1016/0377-8401(92)90034-4

16- Cherney JH, Cherney DJR. Assessing Silage Quality. In: Buxton DR, Muck RE, Harrison JH. Silage Science and Technology. American Society of Agronomy. Madison: USA; 2003. p.141-198.

17- Looper ML, Stokes SR, Waldner DN, Jordan ER. Managing Milk Composition: Evaluating Herd Potential. Cooperative Extension Service College of Agriculture and Home Economics. 2001;104(sn). http://agrilifebookstore.org/

18- Ferreira SF, Guimarães TP, Moreira KKG, Alves VA, Lemos BJM, Souza FM. Caracterização fecal de bovinos. Revista Científica Eletrônica de Medicina Veterinária. 2013;11(20):1-22.

19- Ribas TMB, Neumann M, Horst EH, Cristo FB, Moresco EM, Almeida ER. Effect of inoculants in corn silage on dry matter digestibility, ingestive behavior, performance and carcass of heifers. Semina: Ciências Agrárias. 2021;42(3):1271–1286. https://doi.org/10.5433/1679-0359.2021v42n3p1271

20- Herring WO, Miller DC, Bertrand JK, Benyshek LL. Evaluation of machine, technician and interpreter effects on ultrasonic measures of backfat and longissimus muscle area in beef cattle. Journal of Animal Science. 1994;72(sn):2216-2226. https://doi.org/10.2527/1994.7292216x

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

22- SAS INSTITUTE. SAS/STAT user's Guide: statistics, version 6. 4. ed. North Carolina, v.2, 1993. 943 p.

23- Palmquist DL, Mattos WRS. Metabolismo de lipídeos. In: Berchielli TT, Pires AV, Oliveira SG. Nutrição de Ruminantes. 1st ed. Jaboticabal: Funep; 2006. p.287-310.

24- Rico JE, Souza J, Allen MS, Lock AL. Nutrient digestibility and milk production responses to increasing levels of palmitic acid supplementation vary in cows receiving diets with or without whole cottonseed. Journal of Animal Science. 2017;95(1):436-446. https://doi.org/10.2527/jas.2016.1089

25- Reis ME, Toledo AFD, Silva AP, Poczynek M, Fioruci EA, Cantor MC, Greco L, Bittar CMM. Supplementation of lysolecithin in milk replacer for Holstein dairy calves: Effects on growth performance, health, and metabolites. Journal of Dairy Science. 2021;104(5):5457-5466. https://doi.org/10.3168/jds.2020-19406

26- Sniffen CJ, O'Connor JD, Van Soest PJ, Fox DG, Russell JB. A net carbohydrate and protein system for evaluating cattle diets. II. Carbohydrate and protein availability. Journal of Animal Science. 1992;70(sn):3562-3577. https://doi.org/10.2527/1992.70113562x

27- Van Soest PJ. Nutritional ecology of the ruminant. 2nd ed. Ithaca: Cornell University Press; 1994.

28- Kozloski GV. Bioquímica dos ruminantes. 3 ed. Fundação de Apoio a Tecnologia e Ciencia: Editora UFSM; 2017.

29- Ferreira SF, Freitas Neto MD, Pereira MLR, Melo AHF, Oliveira LG, Neto JTN. Fatores que afetam o consumo alimentar de bovinos. Arquivos de Pesquisa Animal. 2013;2(1):9-19

30- Lawrie RA, Rubensam JM. Ciência da carne. 6nd ed. Porto Alegre: Artmed; 2005. 384p.

31- Silva MR, Heitor EJP, Oliveira DFP, Cervelati KF, Pinheiro MSM. Importância da deposição de gordura em bovinos de corte e sua mensuração através da técnica de ultrassonografia. Pubvet. 2011;5(15):1-11.

32- Cardoso EO, Silva RR, Silva RR, Carvalho GGP, Júnior GT, Souza SO, Lisboa MM, Pereira MMS, Mendes FBL, Almeida VVS, Oliveira AC. Influência do sexo no desempenho, característica de carcaça e viabilidade econômica de bovinos alimentados com dieta de alto grão. Semina: Ciências Agrárias. 2014;35(4Supl):2643-2654. https://doi.org/10.5433/1679-0359.2014v35n4Suplp2643