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EXPELLER SOYBEAN MEAL: EVALUATION OF HOLSTEIN COW PRODUCTION AND IN VITRO RUMINAL KINETIC

Rodrigo Macagnan
Universidade Tecnológica Federal do Paraná, Dois Vizinhos, PR, Brazil,
https://orcid.org/0000-0001-6026-5826

Ana Carolina Fluck
Zootecnista, Dra., Santo Ângelo, RS, Brazil,
https://orcid.org/0000-0001-9133-2446

Olmar Antônio Denardin Costa
Zootecnista, Dra., Santo Ângelo, RS, Brazil,
https://orcid.org/0000-0001-5201-2618

Núbia da Silva Oliveira
Zootecnista, Cascavel, PR, Brazil,
https://orcid.org/0000-0003-4065-9662

Leonardo Piffer de Borba
Universidade Tecnológica Federal do Paraná, Dois Vizinhos, PR, Brazil
https://orcid.org/0000-0003-2028-5712
Email correspondente: leopborba@yahoo.com

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Abstract

We aimed to evaluate the inclusion of expeller soybean meal on the quality and milk production of Holstein cows, as well to estimate and compare the inherent parameters of the *in vitro* ruminal kinetics. Data collection was carried out on a private property, in the interior of the municipality of Dois Vizinhos - Paraná, Brazil. Twenty Holstein cows were used, divided into two treatments: one with the inclusion of expeller soybean meal and the other with conventional soybean meal. The design used was completely randomized with parity. Milk production was evaluated through weighing. Milk samples were collected on days 0, 15, 30 and 45 to evaluate the milk protein, fat, urea nitrogen, lactose and total solids. The *In vitro* ruminal kinetics of convencional and expeller soybean meal was performed at the Universidade Tecnológica Federal do Paraná – Paraná, Dois Vizinhos. The gas pressure and volume measures were taken after 1, 2, 3, 6, 8, 10, 12, 16, 20, 24, 30, 36, 48 and 72 hours of sample incubation. The results obtained were applied in a two-compartmental mathematical model with no latency time in the first compartment for description of ruminal kinetics. Data were analyzed by variance (ANOVA) and compared by the F test. There was no significant difference in any of the variables evaluated from mil production and quality when soybean meal expeller was included in the animals' diet (P>0.05). The expeller soybean meal showed a lower degradation compared to the conventional meal. There were no significant differences for milk production as for concentration of solids in milk.

Keywords Protein degradability, protein sources, milk fat, rumen, undegradable protein.

FARELO DE SOJA EXPELLER: AVALIAÇÃO DA PRODUÇÃO DE VACAS HOLANDESAS E CINÉTICA RUMINAL *IN VITRO*

Resumo

O objetivo foi avaliar a inclusão do farelo de soja expeller na qualidade e produção do leite de vacas holandesas, assim como estimar e comparar os parâmetros inerentes a cinética ruminal *in vitro* do farelo de soja convencional e expeller. A coleta de dados a campo foi realizada em propriedade particular, no interior do município de Dois Vizinhos - Paraná, Brasil. Foram utilizadas 20 vacas holandesas, divididas em dois tratamentos: um com inclusão de farelo de soja expeller e o outro com farelo de soja convencional. O delineamento utilizado foi inteiramente casualizado com paridade. Foi avaliada a produção do leite através de pesagem diária. Amostras de leite foram coletadas nos dias 0, 15 e 30 para determinação de proteína, gordura, nitrogênio ureico, lactose e sólidos totais. A cinética ruminal *in vitro* do farelo de soja convencional e farelo de soja expeller foi realizada na Universidade Tecnológica Federal do Paraná, campus Dois Vizinhos. As leituras de pressão e volume foram realizadas após 1, 2, 3, 6, 8, 10, 12, 16, 20, 24, 30, 36, 48 e 72 horas de incubação. Os resultados obtidos foram aplicados em modelo matemático bicompartimental sem latência no primeiro compartimento para descrição da cinética ruminal. Os dados foram submetidos à análise de variância (ANOVA) e comparados pelo Teste F. Quanto a produção e qualidade do leite, não houve diferenças significativa para as variáveis avaliadas quando incluído o farelo de soja expeller na dieta dos animais (P>0,05). O farelo de soja expeller apresentou uma degradação inferior comparada ao farelo convencional. Não houve diferenças significativas para a produção de leite como para a concentração de sólidos no leite.

Palavras chaves degradabilidade proteica, fontes proteicas, gordura do leite, proteína não degradável no rúmen.

INTRODUCTION

Brazil is the fourth largest milk producer in the world, being only behind the USA, India, China and Germany. However, its production is lower when compared to its potential. This placement is often linked to nutritional deficiencies, genetics, climatic, environmental and economic factors (FISCHER et al., 2012; DE ALMEIDA et al., 2022). With the Normative Instructions 76 and 77 of the Brazilian Ministry of Agriculture, Livestock and Supply, in force in the national territory, producers and technicians are seeking improvement in the milk quality and biosecurity, being the sanitary, feeding and reproductive management the main challenge.

Protein is the second largest nutrient in the diet, after carbohydrates. In the rumen, it can be digested and used for the synthesis of microbial protein (rumen degradable protein - RDP), a product of high biological quality, or pass inert through the degradation of rumen microorganisms and undergo chemical digestion in the abomasum (rumen undegradable protein - RUP). In dairy cattle herds with upward genetics and production, there are higher requirements for amino acids than those found in microbial protein, thus, it is essential to supply higher levels of RUP in the diet, enabling more efficiently to meet these needs (RIBEIRO et al., 2014).

To optimize the passage of intact protein in the rumen to the abomasum, the use of expeller soybean meal in ruminant feeding is widely used. However, the soybean grain, in order to become a meal with direct availability to the animal, must undergo thermal and pressure processes so that the protein is protected from the degradation of ruminal microorganisms, increasing the percentage of the RUP fraction (BRAND and JORDAAN, 2020). This protection is linked to the bonds between carbohydrates and proteins, known as the Maillard reaction, leaving the feeding unavailable to the animal or decreasing its rumen degradability.

Despite the benefits, the expeller soybean meal is more expensive when compared to the conventional sake of its manufacturing process with higher energy consumption during the manufacturing cycle. So, it is necessary to observe if there is an increase in milk production and if its economic value justifies its use. In this order, we aimed to evaluate the expeller soybean *In vitro* ruminal kinetics, as well as its effects on the Holstein cows milk yield, quality and economic parameters.

MATERIAL AND METHODS

Location, area and animals

The assay was carried out in Dois Vizinhos-PR, Brazil, situated at an elevation of 520 m, 25° 44″ South and 53° 04″ West. The climate of the region is characterized as sub-tropical humid mesotherm (Cfa) according to the Köppen classification (Köppen, 1948). The soil of the region is classified as Red Latosol or dystroferric with clayey texture (ALVARES et al., 2013).

The study was carried out in a private ownership farm, whose main activity is dairy cattle. The herd had 60 dairy cows with 30 liters per cow/day mean production, age ranging from 2 to 8 years and of 600 kg/LW.

The animals were housed in a compost barn feedlot system, with a ceiling height of 5 meters and a bed area of 800 m², and 15 m²/animal. The feeding room is separate from the shed, with uninterrupted access to food for animals. Drinking fountains were located in the vicinity of the feeding room, ensuring that the animals had water *ad libitum* after feeding, on their way to bed.

Choice of inclusion levels for the expeller soybean meal

The animals' diet was calculated from the NRC (2001) recommendations for a production of 45 kg/milk/day/animal.

According to the estimate pre-made, the best level of inclusion of expeller soybean meal in replacement of conventional meal in the animals' diet was 50% (Table 1) to provide RUP levels of 35%, as recommended by the NRC (2001). For each, we offer 2 kg/animal daily in both treatments.

Table 1. Nutritional protein requirements of 600 kg lactating cows with expected production of 45 kg/milk/day.

	Nutritional requirements		
Levels (%)[1]	CP (%)[2]	RDP (%)[3]	RUP (%)[4]
Requirements	**15.91**	**10.59**	**5.1**
100	16.37	9.54	6.83
75	16.04	9.56	6.48
50	16.54	10.79	5.78

[1]Levels of inclusion in the diet, [2]Crude protein, [3]Rumen degradable protein, [4]Rumen undegradable protein.

In vivo evaluation

All procedures were approved by the Ethics Committee on the Use of Animals (CEUA - UTFPR, case nº. 2018-02).

Milk production and quality was evaluated of 24 animals with an average production of 40 kg/day and average live weight of 650±50 kg (Table 2). To maintain the homogeneity of treatments, animals were chosen by being in second or third lactation and age from 4 to 6 years.

The experimental design was completely randomized, paired by independent groups, with two treatments: One treatment consisted of 12 animals with the inclusion of expeller soybean meal (ESM) consisting of 45% CP and 65% RUP, the other treatment consisted of 12 animals fed with conventional soybean meal (CSM) consisting of 45% CP and 35% RUP. The amounts administered of each bran in the diets were calculated from the guarantee levels provided by the manufacturing enterprise (Table 3).

Table 2. Production and days of lactation (DOL) of Holstein cows fed or not with expeller soybean meal.

	ESM[1]			CSM[2]	
Animal	Production[3]	DOL	Animal	Production[3]	DOL
99	30	43	7	42	40
397	38	60	693	55	21
529	44	44	105	45	78
159	46	22	683	35	70
698	42	65	4	42	68
160	36	71	72	35	197
398	38	56	674	50	37
3	44	155	10	35	174
695	33	15	467	32	10
435	42	145	600	36	142
61	38	120	853	30	36
103	42	115	12	34	16
MÉDIA	39	76		39	74

[1]ESM: expeller soybean meal, [2]CSM: conventional soybean meal, [3]Production: kg/milk/day.

Analysis of the nutritional composition of diets

Diet samples were collected, weighed and pre-dried in a 55 °C forced-air oven for 72 h and grounded to pass through a 1-mm sieve of a Wiley-type mill™ (Thomas Scientific). Dry matter (DM) contents were determined by drying in an oven at 105ºC for 8 hours (Method 967.03; AOAC, 1998) and ash by placing on muffle furnace (600ºC, 4h). The organic matter (OM) content was calculated as 100 – MM (Method 942.05; AOAC, 1998).

Crude protein (CP) was estimated from the total nitrogen value (N), using the Kjeldahl method (Method 2001.11; AOAC, 2001). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were performed according to the method by Van Soest et al. (1991), adapted by Komarek et al. (1993), using polyester bags with a porosity of 16 µ and the material subjected to a temperature of 110°C in an autoclave for 40 minutes (SENGER et al., 2008). For NDF, alpha-amylase was included (MERTENS, 2002).

Ether extract (EE) analysis was performed using semiautomatic equipment (ANKOM*XT15* Extraction System, ANKOM Technology Corporation, Fairport, NY, EUA) with *filter bags* with porosity of 3 µ (XT4®).

Table 3. Bromatological composition of basal diet ingredients and meal used for experimental diets.

Nutrient, % DM	Diet component					
	Silage of corn	Silage haylage	Soybean hulls	High moisture corn	ESM[1]	CSM[2]
DM[3]	31,0	47,5	88,0	66,0	91,0	88,0
CP[4]	8,7	18,7	10,5	9,2	44,5	47,7
NDF[5]	39,4	59,09	67,07	8,53	33,25	29,09
ADF[6]	22,3	29,02	41,09	0,24	11,16	7,39
Ash	5,0	10,0	4,0	2,0	7,0	7,0
OM[7]	95,0	90,0	96,0	98,0	93,0	93,0
EE[8]	-	-	-	-	7,9	1,2

[1]ESM: expeller soybean meal, [2]CSM: conventional soybean meal, [3]DM: dry matter, [4]CP: crude protein, [5]NDF: neutral detergent fiber, [6]ADF: acid detergent fiber, [7]OM: organic matter, [8]EE: ether extrat.

The diets were provided three times a day, after milking, in a forage:concentrate ratio of 50:50. The forage consisted of corn silage and cowgrass (*Cynodon dactylon*) silage haylage (Table 4), in the vegetative stage, while the concentrate was made from high moisture corn, soybean meal and soybean hulls. In this case, the administration of the expeller soybean meal and the conventional soybean meal was exclusive, that is, included for each animal. Mineral supplementation was provided in the diet itself and adjusted according to the cows requirements.

The experiment was carried out in winter, over 45 days, with 10-days adaption period. Milk was weighed daily and samples were collected for laboratory analysis on days 0, 15 and 30. The milk samples were collected at the first and last milking of the

Table 4. Participation of basal diet ingredients and consumed diet.

Ingredient (% DM)	Diet	
	CSM[1]	ESM[2]
Silage	44	43
Conventional soybean meal	16	10
Expeller soybean meal	0	7
Mineral salt	2	2
Tamponant	1	1
Urea	1	1
Soybean Hulls	11	11
High moisture corn	19	19
Silage haylage	6	6

[1]CSM: conventional soybean meal, [2]ESM: expeller soybean meal.

day and sent to the Associação Paranaense de Criadores de Bovinos Leiteiros da Raça Holstein (APCBRH) for the determination of the levels of protein, fat, total solids, urea nitrogen and lactose. Both diets (Table 5) were *ad libitum* and calculated from the requirements stipulated by the National Research Council - NRC (2001) for dairy cattle.

Table 5. Bromatological composition of experimental diet.

Nutrient	Ingredient	
	CSM[1]	**ESM[2]**
CP[3], % DM	47,70	45,66
ADF[4], % DM	7,39	13,74
NDF[5], % DM	29,09	20,55
RUP[6],% CP	35,00	65,00
RDP[7]% CP	65,00	35,00
DM[8], % DM	88,00	92,00
EE[9], % DM	1,20	8,53

[1]CSM: conventional soybean meal, [2]ESM: expeller soybean meal, [3]CP: crude protein, [4]FB: acid detergent fiber, [5]NDF: neutral detergent fiber, [6]RUP: rumen undegradable protein, [7]RDP: rumen degradable protein, [8]DM: dry matter, [9]EE: ether extrat.

In vitro ruminal kinetics

For the in vitro degradation kinetics assay, three laboratory replicates were used, which generated three gas production profiles during the 72 hours of incubation.

Ruminal inoculum was obtained from two castrated Holstein male cattle (Commission on Animal Use – CEUA UTFPR, 2014-008), castrated, weighing ± 650 kg, kept on pasture and supplemented with 2 kg of soybean meal for 7 days, as recommended by Abreu et al. (2014).

The in vitro analysis of ruminal kinetics was performed in a water bath at 39 ° C. We used 100-mL serum amber bottles sealed with butyl rubber stoppers and aluminum crimp seals. Individually, ground soybean meal samples of approximately 0.5 g were transferred into the bottles and incubated with 40 mL reduced solution and culture medium with 10 mL of rumen inoculum, as previously described by Goering and Van Soest (1970). The equipment used to measure gas pressure and volume is similar to that described by Malafaia et al. (1998) with some modifications suggested by Abreu et al., (2014). The variables evaluated were Vf1: maximum volume of gas production from the fraction of nonfiber carbohydrates; K1: is the specific rate of gas production by degradation of the soluble fraction of rapid digestion; Vf2: maximum volume of gas production from the fraction of fibrous carbohydrates; K2: is the specific rate of gas production for degradation of potentially degradable insoluble fraction of slow digestion (h–1) and L: Lag time. Pressure and volume readings were taken at times 1, 2, 3, 6, 8, 10, 12, 16, 20, 24, 30, 36, 48 and 72 hours after the material was incubated.

Economic feasibility of using the expeller soybean meal.

The prices of soybean meal and milk used for the financial calculations considered the database of the "Luiz de Queiroz" College of Agriculture (ESALQ), referring to the month of August and September of the year 2018.

Statistical analysis

Data on the effects of soybean meal on milk production and quality were subjected to analysis of variance (ANOVA) and the means were compared using the F test. The mathematical model used was:

$$Y_i = \mu + \alpha_i + \varepsilon_i$$

Where: (Y_i) = estimated mean for treatments, (μ) = parameter inherent to the model, (α_i) = treatment effect and (ε_i) = experimental error. Data were analyzed using the mixed models procedure (Mixed) of the SAS® University Edition (SAS/STAT®□ 13.1 User's Guide, 2013).

In vitro ruminal kinetics were estimated using a two-compartmental model with no latency in the first compartment, as proposed by Zwietering et al. (1990) and Schofield et al. (1994), which consists of considering the fraction of fast digestion and slow digestion:

$$V_t = V_{f1}[1 - \exp(-k_1 t)] + V_{f2}\exp\{-\exp[1 + k_2 e(L - t)]\} + \varepsilon$$

Where: V_t = as the asymptotic gas volume reached for a single pool substrate; Vf_1 and Vf_2 describe the volume of asymptotic gas production of these two compartments, respectively. Parameter k_1 is the specific rate of gas production by degradation of the soluble fraction of rapid digestion, and k_2 is the specific rate of gas production for degradation of potentially degradable insoluble fraction of slow digestion (h^{-1}); and T = incubation time (h).In this model, the fast digesting pool is fermented as a first-order process without lag, and the second pool follows a logistic pattern with a lag time (λ); h^{-1}) To estimate this parameters, we used the Non-linear model (NLIN) in SAS® University Edition program (SAS/STAT®□ 13.1 User's Guide, 2013).

RESULTS AND DISCUSSION

Milk production and quality

There was no difference (P>0.05) for all the parameters evaluated to determine the milk yield and quality. The average milk fat (Table 6) did not show significant differences, however, there was a decline in milk fat when cows was fee with expeller soybean meal (ESM) when compared to that were fed conventional soybean meal (CSM).

Table 6. Total production and milk quality of Holstein cows fed or not with expeller soybean meal.

	TRATAMENTS			
Components	ESM[1]	CSM[2]	ERROR	P>F
PFR[3], %	1.1	0.96	0.053	0.063
FAT[4], %	2.99	3.44	0.168	0.066
PROT[5], %	3.15	3.11	0.064	0.64
LACT[6], %	4.75	4.75	0.054	0.91
SOL[7], %	11.76	14.92	0.207	0.09
MUN[8], %	14.92	16.01	1.48	0.24
PROD[9], L	41.7	41.6	2.36	0.892

[1]CSM: expeller soybean meal, [2]ESM: conventional soybean meal, [3]PFR: protein:fat ratio, [4]FAT: fat, [5]PROT: protein, [6]LACT: lactose, [7]SOL: solids, [8]MUN: milk urea nitrogen, [9]PROD: milk yield.

Palmquist et al. (2017) describe that sources of unsaturated lipids stimulate propionate-producing bacteria, causing a decrease in the production of acetate, the main precursor of milk fat. This process also occurs with the forage:concentrate ratio, when the roughage part of the diet decreased and concentrates increased. Thus, ESM increased the levels of EE in the diet, which resulted in a decrease in fat levels, but it was not significant.

There was no effect of partial replacement of conventional soybean meal by ESM on milk protein levels (P>0.05), however, they were higher than those found by Giallongo et al. (2015), who compared the use of expeller soybean meal with solvent treatment to expeller soybean meal extruded at different temperatures, observed averages of 2.9% of protein in the milk of Holstein cows fed with thermally treated soybean meal and with the use of solvent.

The protein:fat ratio (PFR) showed no significant difference for treatments (P>0.05). According to Zschiesche et al. (2020), milk PFR can be a simple rumen parameter, it can demonstrate possible rumen problems such as subclinical acidosis or subclinical ketosis, based on the protein:fat ratio found in milk contents.

The results of total solids did not show a significant difference (P>0.05), however, for animals that consumed ESM there was a tendency to be lower due to the decrease in the percentage of fat.

Sources with high RUP are provided to lactating cows in order to increase the total solids of the animals as they would increase protein concentrations and maintain fat concentrations (LOPES et al., 2019; ERIKSON; KALSCHEUR, 2020). In this study, the opposite was observed, fat and solid contents decreased and protein remained.

Lactose levels were not influenced by the partial replacement of soybean meal by ESM (P>0.05), however they were higher than the levels reported by Giallongo et al. (2015), with average values for treatments with the inclusion of heat-treated soybean meal 4.71%.

Lactose plays a fundamental role in milk production and factors such as mastitis lead to productive losses, due to the presence of tissue damage in the mammary gland, presenting impairment in the synthesis of lactose, and consequently, reduction in milk production, due to lactose presenting a role of osmotic regulation of milk (RIBAS et al., 2015; COSTA et al., 2019; COSTA et al., 2020). Giallongo et al. (2015) observed that diets with higher levels of RUP increase the consumption of DM, however, there are no changes in the production of milk and lactose, also observed in this study.

The averages for the milk urea nitrogen (MUN) showed no significant difference (P>0.05), however, the results of the ESM were inferior to the CSM. ESM, because it has a high RUP, provides a greater supply of amino acids in the small intestine for chemical digestion to occur in this organ, with this mechanism there is a decrease in ruminal degradation and consequently a reduction in ammonia levels (FESSENDEN et al., 2019).

A MUN it is frequently used to assess protein levels and the synchronization of carbohydrate and protein degradation in the rumen, its adequate levels are from 11 to 15 mg/dl (NRC, 2001). Values above those mentioned can generate reproductive problems in animals, such as decreased fertility, due to increased pH of the reproductive tract (CHENG et al., 2015; RABOISSON et al., 2017).

The results for the average milk yield showed no significant difference (P>0.05). These values may be a reflection of a good nutrition, as the diets were calculated to meet all the requirements of the animals, in CP, RUP, RDP, energy and other nutrients.

In an experiment comparing the response of the expeller soybean meal and by -product of fermented and processed corn grain (*by pass*) in relation to conventional soybean meal in the feeding of Holstein cows, no increase in milk production was observed for both treatments with soybean meal (44 kg/day) (FESSENDEN et al., 2016). These results are in agreement with those observed in this work, since there was no significant difference for this variable.

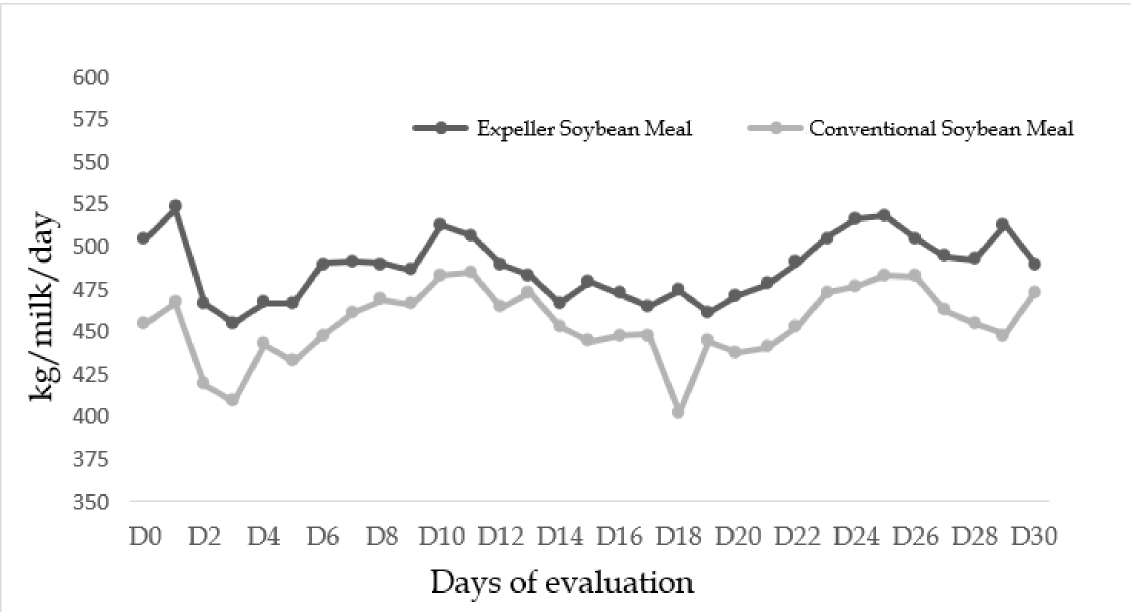

Figure 1 - Variation of milk yield produced by animals during the experimental period.

The supplementation of high levels of RUP in dairy cows may not be satisfactory when the animals are fed with carbohydrate sources of high rumen degradation, such as wet grain, because there is an imbalance, with no stimulus for the synthesis of microbial protein due to the low quantity of rumen undegradable protein (HUMER et al., 2019; SANTOS et al., 2020).

In vitro ruminal kinetics

It was observed that the parameter Vf_1 was higher for the conventional soybean meal (Table 7), demonstrating the greater degradation in the parameter of rapid degradation in relation to expeller soybean meal.

In relation to conventional soybean meal, o expeller soybean meal showed a higher volume of degradation in Vf_1, however, the k_1 was smaller than the conventional soybean meal, indicating a lower rate of degradation of the fraction of rapid degradation due to the thermal process carried out during its manufacture.

Table 7. Parameters of *in vitro* ruminal degradation kinetics do conventional soybean meal and expeller soybean meal.

Parameters	ESM[1]		CSM[2]	
	Estimated	Standard error	Estimated	Standard error
Vf_1[3], mL/0,1 g de DM	15.2635	7.845	13.2045	5.3159
K_1[4], h^{-1}	0.1724	0.127	0.2506	0.0995
Vf_2[5], mL/0,1 g de DM	6.2376	8.7647	10.5911	5.4409
K_2[6], h^{-1}	0.0317	0.0409	0.0318	0.0141
L[7], hours	13.1548	34.9453	4.4108	11.8662

[1]ESM: expeller soybean meal, [2]CSM: conventional soybean meal, [3]Vf_1: maximum volume of gas production from the fraction of nonfiber carbohydrates, [4]K_1: specific rate of gas production by degradation of the soluble fraction of rapid digestion, [5]Vf_2: maximum volume of gas production from the fraction of fibrous carbohydrates, [6]K_2: specific rate of gas production for degradation of potentially degradable insoluble fraction of slow digestion, [7]L: Lag time.

On the other hand, the Vf_2 of the ESM was lower, due to the high latency period that it had in relation to the conventional bran, thus reducing the degradation time of the fractions of slow degradation, generating a smaller volume of gas produced.

A latency period was observed for both brans evaluated in the slow degradation compartment, however, the CSM presented a lower latency time. The high latency period of the ESM demonstrates that the processing was successful, presenting rumen protection and bypassing this protein.

Harper et al. (2019) cite that heat treated soybean meal (expeller) has higher levels of RUP. This procedure causes the *in natura* soybean protein to be denatured (CHENG et al., 2017), transforming it into rumen undegradable protein or escape protein (SAVARI et al., 2018). When evaluated at the rumen level, it increases the latency period by hindering the degradation of rumen bacteria to food.

The behavior of the soybean meal degradation curves was exponential (Figure 2), where its maximum exponential growth was in the first hours of incubation. The highest levels of accumulated gases were around 36 h after samples incubation. Afterwards, production remained stable, with gas production of 19.41 and 22.09 mL/0.1 g of DM, for the expeller soybean meal and conventional soybean meal, respectively.

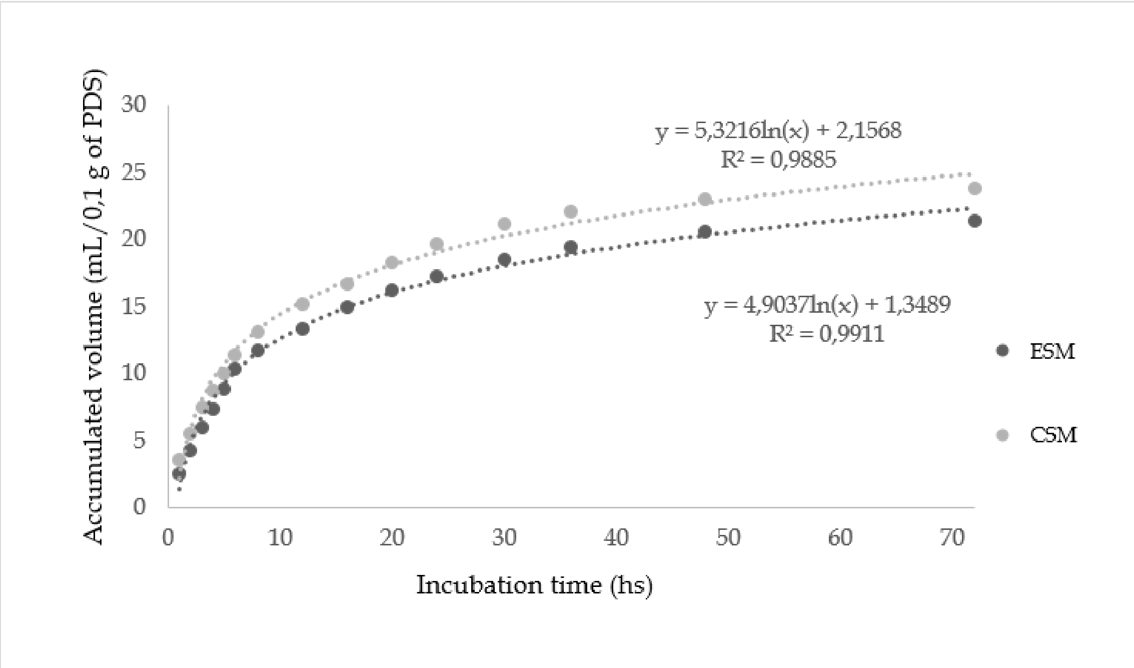

Figure 2 – *In vitro* degradation curve of expeller soybean meal e conventional soybean meal.

The highest rate of protein degradation occurs in the first few hours of feeding, especially when concentrated foods are provided, such as soybean meal. This is due to the high content of fractions A, B1 and B2 of these foods, and these fractions are rapidly degraded in the rumen (PEGORARO et al., 2017).

In addition, a high EE content of the expeller soybean meal (Table 5), which may also have interfered with a lower degradation. Furthermore, diets containing levels of ether extract above 7% in DM can decrease bacterial degradation and the rate of ruminal fermentation in animals (GRANJA-SALCEDO et al., 2017).

According to the parameters studied, they showed that the protein is protected against microbial attack, its degradation curve changed due to the high EE content and the high latency time present in this food.

Cost-effective use of expeller soybean meal

The purchase of the ESM, which took place in 2018, resulted in a higher expense compared to the CSM, which was R$ 18.00 more than the other.

On the other hand, due to the difference generated in the production of animals from this batch, they produced 0.1 liters more than the CSM batch, but the revenue generated is not able to cover the expenses of purchasing the inputs. The result per cow in the period was R$ -10.53 and a loss per period of R$ -126.36.

Tabela 8. Demonstration of the economic result of supplementation with ESM.

Variables	CSM[1]		ESM[2]
Days	45		45
Number of cows	12		12
Meal price, R$	1,80		2,00
Amount given to animals, Kg	5		3 (CSM) + 2 (ESM)
Expenses, R$	405		423
Expense for using the ESM, R$		18,00	
Price paid/liter, R$	1,66		1,66
Production, L	41,60		41,70
Production difference, L	0,10		
Revenue from using the ESM		7,47	
Profit/cow, R$		- 10,53	
Profit/period, R$		- 126,36	

[1]CSM: conventional soybean meal, [2]ESM: expeller soybean meal.

For the inclusion of ESM to be beneficial, the animals should produce more kg/milk/day to justify the higher cost of purchasing the product. The economic evaluation of the inclusion of ESM shows that when animals are fed a balanced diet, according to their production, they tend to produce a satisfactory amount of milk, without the need to use expensive products for the production system.

This financial evaluation demonstrates that the use of the expeller soybean meal, under the conditions of the experiment, was not satisfactory, causing losses due to its use.

CONCLUSION

The expeller soybean meal showed lower degradation in *in vitro* ruminal kinetics when compared to conventional soybean meal.

No differences were observed in milk production and quality for the evaluated treatments. Thus, under the conditions of this study, the use of the expeller soybean meal was more expensive, not justifying its use.

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