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FEED INTAKE OF SHEEP RECEIVING RATION WITH ADDITION OF PASSION FRUIT PEEL MEAL

Sílvia Cristina de Aguiar[1*], Luiz Juliano Valério Geron[1], Gabriel Maciel Nunes[2], Jocilaine Garcia[1], Joilma Toniolo Honório de Carvalho[2], Ana Paula da Silva[2]

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ABSTRACT - Part of the costs of animal production is food, and consequently, several alternatives have been examined for use as co-products, such as passion fruit peel meal (PFP). The objective of this study was to evaluate the dry matter (DMI), nutrient intake, feeding behavior, and physiological parameters of sheep receiving PFP in their ration. Four mixed breed sheep were with a mean body weight of 38.4 kg and distributed in a 4 × 4 Latin square. The experimental diet was formulated with 50% corn silage and 50% concentrate (dry matter [DM] basis), to contain 16% crude protein (CP) and 70% total digestible nutrients, with the addition of PFM to the feed at 0%, 1.6%, 5.8%, and 8.9% based on DMI. The addition of PFP did not affect ($P > 0.05$) DMI and nutrients, with an average DMI of 838.51 g d^{-1}, 2.21% of body weight, and 54.59 g $kg^{-0.75}$. The addition of PFP to the ration did not change the feed intake of DM and nutrients. The PFP did not change the ingestive behavior of sheep during the dawn, morning, and afternoon. However, an increase in the intake time and leisure time was observed during the night. PFP did not influence any of the physiological variables; however, the high temperature during the execution of the experiment caused animal discomfort both in the morning and in the afternoon.
Keywords: by-products, feed intake, leisure, ruminant, temperature.

CONSUMO DE RAÇÃO ADICIONADA DE FARELO DE CASCA DE MARACUJÁ-AZEDO DE OVINOS

RESUMO - Parte dos custos de produção animal ocorre com a alimentação e, devido a isso, várias alternativas são pesquisadas para o uso de coprodutos como, por exemplo, o farelo de casca de maracujá. Desta forma, objetivou-se avaliar o consumo de matéria seca (CMS) e nutrientes, comportamento ingestivo e parâmetros fisiológicos de ovinos recebendo farelo de casca de maracujá-azedo (FCM) na ração. Foram utilizados 4 ovinos sem raça definida, pesando 38,4 kg de peso corporal e distribuídos em um quadrado latino 4×4. A dieta foi formulada com 50% de silagem de milho e 50% de concentrado com base na MS para conter 16% de proteína bruta (PB) e 70% de nutrientes digestíveis totais, diferindo com a adição ou não de FCM à ração: 0%; 1,6%; 5,8% e 8,9% de FCM com base no CMS. A adição do FCM não alterou significativamente o CMS e nutrientes em ovinos, com médias de 838,51 g/dia, 2,21% do peso corporal e 54,59 g/$kg^{0,75}$. A adição do farelo de casca de maracujá-azedo (FCM) à ração de ovinos não alterou o consumo de MS e nutrientes. O FCM não alterou o comportamento ingestivo dos ovinos nos períodos da madrugada, manhã e tarde. Entretanto, foi observado aumento no tempo de ingestão e no tempo de ócio durante o período da noite. O FCM não influenciou nenhuma das variáveis fisiológicas, porém, a elevada temperatura durante a execução do experimento causou desconforto aos animais, tanto no período matutino quanto vespertino.
Palavras-chave: coproduto, ingestão, ócio, ruminante, temperatura.

INTRODUCTION

In livestock, most of the production costs are for feed, and consequently, new options and technologies should be sought to improve animal production and obtain greater productivity. Because of its large agricultural production, Brazil produces a wide variety of fruits, which because of the agro-industrial process to which they are submitted, generate large quantities of by-products. Because of the substantial production of by-products, there is a need to discover new uses, such as an alternative source of food for animal production (VIEIRA et al., 2017).

Alternative foods or by-products, such as waste originating from agricultural production and agribusiness, can be used as ingredients in animal feed and could play a major role in the economics of a production system. Several residues generated by agricultural crops can be used in animal feed; thus, reducing environmental contamination and reducing production costs associated with animal feed (REGO et al., 2019). The use of by-products from agribusiness has two main advantages: the reduction of costs for feed and the use of residues from food processing, which contributes to the sustainability of the system (KUHN et al., 2015).

[1]Docente do Departamento de Zootecnia (DZO), Universidade do Estado de Mato Grosso (UNEMAT), Av. Tancredo Neves, 1095 - Cavalhada II, Cáceres, Mato Grosso, Brazil, Zip Code: 78200-000. E-mail: scaguiar@unemat.br. *Correspondence Author.
[2]Acadêmico do Curso de Zootecnia, Universidade do Estado de Mato Grosso (UNEMAT), Av. Tancredo Neves, 1095 - Cavalhada II, Cáceres, Mato Grosso, Brazil, Zip Code: 78200-000.

Brazil stands out as the largest producer and exporter of passion fruit in the world because of its edaphoclimatic conditions, which are favorable for the development of this crop. Among the commercially exploited species in Brazil, passion fruit or yellow passion fruit (*Passiflora edulis* f. *Flavicarpa Sims*), belonging to the Passifloraceae family, is the most widely cultivated (BOTELHO et al., 2019). According to the Brazilian Institute of Geography and Statistics (IBGE, 2015), the harvested area for passion fruit is just over 50,000 ha, with a production of approximately 690,000 t, exhibiting a decrease in production. The entire production of passion fruit represents approximately 3.5% of the total fruit production in Brazil.

According to ZERAIK et al. (2012), passion fruit peel presents approximately 50% of the fruit mass and with the large production of juice, the peel is a good by-product. Additionally, passion fruit peel has a chemical composition with a greater amount of nutrients than the pulp and is a good source of fiber and pectin. Its residues exhibit variation in the chemical composition according to processing methods, the varieties of passion fruits, and the proportions of peels and seeds contained in the material (GIORDANI JÚNIOR et al., 2014).

The passion fruit by-product can be used as an alternative food to partially replace roughage in animal feed, as long as the ether extract (EE) level is observed such that it does not exceed 6% to 7% of dry matter (DM), thereby not interfering with ruminal fermentation, fiber digestibility, or diet pass rate (AZEVEDO et al., 2011). The objective of this study was to evaluate the effects of adding 0.0%, 1.6%, 5.8%, or 8.9% of passion fruit peel meal (PFP), based on the dry matter intake (DMI), to sheep ration on feed intake, ingestive behavior, and physiological parameters.

MATERIAL AND METHODS

Four castrated male crossbred sheep with average body weight (BW) of 38.4 kg were used. The animals were housed in metabolic cages suitable for urine collection. Each cage had a waterer and a feeder, and the floor was made of slatted wood with the initial part covered with rubber to provide comfort for the animals. The sheep were wormed with an ivermectin product 15 d before the beginning of the experimental period. The animal feed consisted of a 50:50 roughage-to-concentrate ratio. The roughage used was corn silage and the concentrate consisted of 35% ground corn and 15% soybean meal (Table 1).

TABLE 1 - Proportion of ingredients used in the feed, chemical composition of corn silage and total mixed ration (TMR) (DM basis).

Ingredients		TMR (%)
Corn silage		50.0
Concentrate composition:		
Ground corn		35.0
Soybean meal		15.0
Nutrients (%)	**Corn silage**	**TMR**
Dry matter	32.14	61.50
Organic matter	94.37	96.18
Crude protein	10.07	16.77
Ether extract	4.91	5.10
Neutral detergent fiber	55.26	38.52
Acid detergente fiber	31.16	18.51
Total carbohydrates	79.88	74.29
Non-fiber carbohydrates	24.12	35.76
Ash	5.63	3.82
TDN	53.30[1]	69.63[2]

[1]Determined according to the equation proposed by Kearl (1982) for roughage silage (% TDN = - 21.9391 + 1.0538% CP + 0.9736% NNE + 0.03316% EE + 0.4590% CF), [2]Determined according to the equation proposed by Kearl (1982), for protein ingredients [% TDN = 40.3227 + 0.5398 (%CP) + 0.4448 (% NNE) + 1.4218 (% EE) – 0.7007 (% CF)].

The experimental diet was formulated according to the recommendations proposed by the NRC (2007), containing 70% total digestible nutrients and 16% crude protein (CP) (DM basis). Daily, 10 g of mineral supplement was provided for each animal, to which the concentrate was added at the time of feeding.

The chemical composition of the mineral salt used consisted of calcium (Ca) at 120 g kg^{-1}, phosphorus (P) 85 g kg^{-1}, sulfur (S) 16 g kg^{-1}, sodium (Na) 148 g kg^{-1}, cobalt (Co) 50 mg kg^{-1}, copper (Cu) mg kg^{-1} 500, selenium (Se)16 mg kg^{-1}, and zinc (Zn) 4,800 mg kg^{-1}. The experimental treatments differed by the amount of PFP included (Table 2) and consisted of four treatments: no PFP (0% PFP intake on a DM basis), 15 g d^{-1} of PFP (1.6% PFP intake on a DM basis), 45 g d^{-1} PFP (5.8% PFP intake on a DM basis), and 75 g d^{-1} PFP (8.9% PFP intake on a DM basis).

The analyses of DM (method no. 934.01), organic matter (method no. 924.05), CP (method n° 920.87), and EE (method n° 920.85) of the samples were conducted according to the AOAC (1990). Neutral detergent fiber (NDF) was determined according to Van Soest et al. (1991) and acid detergent fiber (ADF) according to method n° 973.18 (AOAC, 1990). Total carbohydrates (TC) were obtained using Equation 1 (SNIFFEN et al., 1992):

$$TC = 100 - (\%CP + \%EE + \%Ash) \qquad \text{(Equation 1)}$$

Non-fiber carbohydrates were determined by the difference between TC and NDF (without correction for protein and ash).

TABLE 2 - Chemical composition of the PFP meal used in the experiment.

Nutrient	Chemical composition (%)
Dry matter	90.52
Organic matter	97.77
Crude protein	11.67
Ether extract	1.29
Neutral detergente fiber	23.53
Acid detergent fiber	18.89
Ash	2.23

To assess feeding behavior, the following behavioral measures were determined for the feeding animals, ruminating while standing, ruminating while lying, standing, lying, drinking water, and other activities. The ingestive behavior of each sheep was determined visually, in 5 min intervals (sampling scan) during 24 h, to determine the time spent in leisure, feeding, and rumination (JOHNSON and COMBS, 1991). These observations were made every 14 d, totaling 4 d of observations during the experimental period. The behavioral data were distributed into four periods: morning (0600–1200 h), afternoon (1200–1800 h), night (1800–2400 h), and dawn (2400–0600 h). During nighttime observations, the environment was maintained with artificial lighting.

The evaluations of the physiological parameters and climatic variables were conducted during 3 d of collection and at two times: in the morning (0700 h and 1100 h) and afternoon (1300 h and 1700 h). The variables evaluated were room temperature, front body temperature (FBT), rear body temperature (RBT), rectal temperature, dry-bulb temperature, wet-bulb temperature, and respiratory rate (RR). To evaluate the physiological parameters (FBT, RBT, and rectal temperature), a digital infrared thermometer was used to measure body temperatures. To obtain the body temperatures of the front and rear, the thermometer was positioned in the region of the palette and femur. To measure the rectal temperature, a clinical thermometer was inserted directly into the rectum of the animal for 2 min. The RR was obtained by visual observation of the lateral flank movements for 15 s, and the values multiplied by four to calculate the RR/min.

Using the model proposed by THOM (1959), the temperature and humidity index (THI) were calculated according to Equation 2:

$$THI = 0.72 \times (DBT + WBT) + 40 \qquad \text{Equation 2}$$

Where:

DBT = dry-bulb temperature and
WBT = wet-bulb temperature.

To evaluate the THI, the classification proposed by Souza et al. (2010) was used, with THI < 74 (animals within adequate thermal comfort), 74 ≤ THI < 79 (warm environment, where thermal discomfort starts, which can cause health problems and reduced performance), 79 ≤ THI < 84 (very hot environment, where the THI indicates danger, which can have very serious consequences for animal health, which require precautions to avoid losses in production), and THI > 84 (extremely hot environment, with a very serious health risk, indicating an emergency needing urgent measures to avoid loss of the herd).

The data obtained were interpreted by an analysis of variance, using the GLM procedure in SAS (2001) software. The mathematical model used for the analysis of variance is as follows (Equation 3):

$$Yijk = \mu + Ai + Pj + Tk + eijk \qquad \text{(Equation 3)}$$

Where:
Yijk = observed variables
μ = overall average,
Ai = effect of animal i, ranging from 1 to 4,
Pj = effect of period j, ranging from 1 to 4,
Tk = effect of treatment k, ranging from 1 to 4 and
eijk = random error.

This study was approved by the Ethics Committee on the Use of Animals (CEUA) of the Universidade do Estado de Mato Grosso (UNEMAT), and animal studies were conducted according to ethical standards.

RESULTS AND DISCUSSION

The addition of PFP to the feed did not change (P > 0.05) DM and nutrient intake expressed in g d^{-1}, % BW and g $kg^{-0.75}$ (Table 3) and the average value obtained for DMI was 838.51 g d^{-1}. The amount of PFP ingested by the animals was probably not enough to promote any change in consumption. Lousada Júnior et al. (2005) studied the nutritional value of by-products from fruit processing (pineapple, acerola, guava, passion fruit, and melon) in sheep ration and found that the DMI of guava, passion fruit, and melon by-products were similar; however, they were superior to the DMI of acerola by-products. The same authors observed an average for DMI of passion fruit by-product of 1,200.9 g d^{-1}, which was higher than the value obtained in the present experiment, probably because the by-product was the only source of food supplied to the animals.

TABLE 3 - Average daily dry matter (DMI) and nutrients intake and coefficients of variation (CV) of sheep receiving diets with addition of passion fruit peel meal.

Feed intake	Passion fruit peel meal (% DMI)				CV%	Regression
	0	1.6	5.8	8.9		
	Dry matter intake (DMI)					
g/day	838.91	898.55	777.09	839.50	14.81	Y = 838.51
% BW	2.16	2.35	2.02	2.29	11.18	Y = 2.21
g/kg$^{0.75}$	53.88	58.58	50.45	55.42	13.10	Y = 54.59
	Organic matter intake					
g/day	810.72	870.20	735.88	822.294	17.48	Y = 809.94
% BW	2.08	2.27	1.95	2.17	12.39	Y = 2.12
g/kg$^{0.75}$	52.08	56.50	48.63	53.89	12.75	Y = 52.78
	Crude protein intake					
g/day	138.37	152.51	125.34	139.93	21.26	Y = 139.04
% BW	0.36	0.39	0.33	0.37	14.10	Y = 0.36
g/kg$^{0.75}$	9.32	9.74	8.27	9.36	15.76	Y = 9.17
	Ether extract intake					
g/day	44.97	46.39	40.63	43.65	14.85	Y = 43.91
% BW	0.11	0.12	0.10	0.11	13.05	Y = 0.11
g/kg$^{0.75}$	2.89	3.02	2.64	2.88	13.32	Y = 2.86
	Neutral detergent fiber intake					
g/day	279.20	323.83	268.35	285.20	19.25	Y = 289.14
% BW	0.71	0.84	0.69	0.75	17.76	Y = 0.75
g/kg$^{0.75}$	17.82	21.09	17.40	18.76	17.96	Y = 18.77
	Acid detergent fiber intake					
g/day	161.85	167.15	149.72	146.60	15.05	Y = 156.33
% BW	0.41	0.43	0.39	0.39	13.92	Y = 0.40
g/kg$^{0.75}$	10.41	10.90	9.73	9.66	14.01	Y = 10.17
	Total carbohydrates intake					
g/day	620.78	670.94	580.80	630.37	14.24	Y = 625.72
% BW	1.59	1.76	1.51	1.68	11.76	Y = 1.63
g/kg$^{0.75}$	39.85	43.72	37.70	41.64	12.19	Y = 40.73
	Non-fiber carbohydrates intake					
g/day	341.53	347.06	312.40	345.11	11.10	Y = 336.52
% BW	0.88	0.91	0.81	0.92	7.96	Y = 0.88
g/kg$^{0.75}$	22.02	22.63	20.30	22.87	8.53	Y = 21.95

Parente et al. (2009) evaluated the productive performance of sheep in feedlots fed different diets containing milled corn + soy + Tifton 85 hay (control diet) and diets containing cashew, passion fruit, and leucena hay and observed that the DMI of the diet containing passion fruit did not differ from that of the control diet. CP intake was also not influenced by the addition of PFP, with an average of 139.04 g $animal^{-1}$ d^{-1}. Cruz et al. (2011) observed that the values for CP, expressed in g d^{-1}, were 161.1, 212.2, and 196.9, respectively, with the addition of 10%, 20%, and 30% PFP dehydrated in elephant grass silage for lambs, with no difference when consumption was expressed in % BW, with an average of 0.70. The values obtained by the authors were higher than those found in the present study, with the treatment with the lowest addition of PFP being the closest to the CP intake obtained here, probably because of the low amount of PFP added to the feed. EE intake was also not influenced ($P > 0.05$) by the addition of PFP, with an average of 43.91 g $animal^{-1}$ d^{-1}. The amount of PFP ingested by the animals was probably not sufficient to promote changes in EE consumption among the treatments studied here.

There was no significant difference ($P > 0.05$) in NDF and FDA intake, with averages of 289.14 and 156.33 g $animal^{-1}$ d^{-1}, respectively. The means of NDF intake, both in g d^{-1} and in % BW in the present study were lower than those recorded by Cruz et al. (2011), who found that the addition of dehydrated PFP to elephant grass changed the NDF intake in g d^{-1}, with an increase of 4.16% for each 1% of PFP. This demonstrated that the higher the level of inclusion of PFP in the diet, the greater the amount of fiber ingested, which could compromise consumption.

Because of the limited available data on the chemical composition of the passion fruit by-products, much attention should be paid to its chemical composition because its residues vary in composition depending on the processing method, the varieties of passion fruit used, and the proportions of peels and seeds contained in the material. In this residue, the presence of pectin in the peel and a high concentration of lipids in the seeds should be highlighted because they contributed to its energy fraction in the diets. On the other hand, excess fat can impair the use of dietary fiber (GIORDANI JÚNIOR et al., 2014).

The addition of PFP did not influence (P > 0.05) animal ingestive behavior during the 24 h period (Table 4). Carvalho et al. (2008) evaluated diets containing cocoa bran (0, 10, 20, and 30%) in the feed of Santa Inês sheep and found no significant differences in animal ingestive behavior. Figueiredo et al. (2013) studied the ingestive behavior of sheep fed different fiber sources and found that sheep fed a higher fiber source (Tifton hay) spent more time feeding and less time on leisure compared to animals fed a lower fiber source (sugarcane silage).

TABLE 4 - Ingestive behavior of sheep receiving diets with addition of passion fruit peel meal (PFP).

Activities (minutes)	PFP (% DMI[1])				Regression	P
	0	1.6	5.8	8.9		
Feeding	246.25	245.00	198.75	230.00	Y = 230.0	0.163
Ruminating while standing	25.00	47.50	40.00	38.75	Y = 37.81	>0.05
Ruminating while lying	361.25	383.75	343.75	367.50	Y = 364.06	>0.05
Standing	170.00	101.25	143.75	151.25	Y = 141.56	0.213
Lying	565.00	605.00	616.25	575.00	Y = 590.31	>0.05
Drinking water	10.00	6.25	28.75	12.50	Y = 14.37	0.086
Other	61.25	53.75	65.00	63.75	Y = 60.93	>0.05

[1]Intake of PFP in relation to dry matter intake (DMI). *P>0.05*.

PFP has a high fiber content. The PFP levels in the present study may have not been sufficient to promote changes in ingestive behavior in the 24 h period and occurred because the fibrous portion of the diet (NDF and FDA) was at insufficient quantities (1.6%, 5.8%, and 8.9% of DMI) to effect consumption, rumination, and leisure. Other factors observed were the NDF and ADF content of the PFP used. The literature reports NDF and ADF values for PFP of 59.0% and 49.2%, respectively (CRUZ et al., 2011). In the present study, the PFP had values for NDF and ADF of 23.53% and 18.89%, respectively. The lack of effect of PFP on the ingestive behavior in this study may also have been caused by the low content of the fibrous fraction of the PFP used.

The intake of PFP did not influence the ingestive behavior in the morning, afternoon, or early morning; however, there was an influence on the nighttime feeding time (P = 0.024) and time lying idle (P = 0.026, Table 5). The feeding behavior exhibited cubic behavior ($Y = 61.25 + 25.7776 - 8.33517x^2 + 0.632378x^3$, $r^2 = 36.14\%$), where a longer consumption time was observed (84.14 min.) for the intake of 2.3% PFP and a shorter time (49.96 min.) for the intake of 6.8% PFP.

For the intake of 6.9% PFP, feed intake time increased again, reaching its maximum at the dose of 8.9% PFP (76.25 min). This fact can be explained by the considerable presence of pectin, which, according to Van Soest (1994), presents rapid degradability in the rumen, requiring less rumination time, and consequently, a higher rate of food passage through the digestive tract, resulting in more time spent on the ingestion of feed.

The time spent lying down revealed quadratic behavior ($Y = 126.849 + 18.7127x - 1.84052x^2$, $r^2 = 19.37$), with less time lying down for 0% PBP intake and more time lying down for ingestion of 5.8% PFP. This result was related to the shorter time spent on ingestion (53.75 min) and rumination (5.00 min) for the treatment with 5.8% DMI of the PFP meal, which allowed the animals to lie down longer (183.75 min). Different results were found by Macedo et al. (2007), who evaluated the ingestive behavior of sheep fed levels of roughage substitution by fresh orange pomace (25%, 50%, and 75%), and found no significant difference in feed intake; however, they observed that increasing levels of orange pomace decreased rumination time in min d^{-1}.

It is noteworthy that the residues of passion fruit exhibit variation in chemical composition, according to the processing methods, cultivars used, and the proportion of peels and seeds. Thus, the variation in its composition can influence ingestive behavior because food, as well as its fibrous portion, can influence feed intake, rumination, and leisure time of the animals. The average room temperature, DBT, and WBT of the sheep housing during the four experimental periods are shown in Table 6.

TABLE 5 - Ingestive behavior of sheep receiving diets with addition of passion fruit peel meal (PFP).

Activities (minutes)	PFP (%DMI[1])				Regression	CV(%)
	0%	1.6%	5.8%	8.9%		
			Morning			
Feeding	112.50	105.00	96.25	105.00	Y = 104.68	14.64
Ruminating while standing	1.25	8.75	7.50	7.50	Y = 6.25	73.03
Ruminating while lying	65.00	82.50	61.25	88.75	Y = 74.37	25.96
Standing	26.25	16.25	26.25	25.00	Y = 23.43	48.39
Lying	132.50	136.25	133.75	117.50	Y = 130.00	29.62
Drinking water	3.75	3.75	20.00	6.25	Y = 8.43	121.86
Other	23.75	13.75	18.75	13.75	Y = 17.50	49.48
			Afternoon			
Feeding	67.50	52.50	47.50	46.25	Y = 53.43	20.70
Ruminating while standing	2.50	15.00	13.75	16.25	Y = 11.87	86.80
Ruminating while lying	86.25	75.00	78.75	72.50	Y = 78.12	40.98
Standing	52.50	30.00	61.25	47.50	Y = 47.81	60.88
Lying	135.00	167.50	130.00	156.25	Y = 147.18	27.18
Drinking water	3.75	2.50	6.25	1.25	Y = 3.43	100.68
Other	12.50	18.75	22.50	20.00	Y = 18.43	54.65
			Night			
Feeding	61.25	83.75	53.75	76.25	[2]	15.42
Ruminating while standing	11.25	13.75	5.00	12.50	Y = 10.62	103.45
Ruminating while lying	62.50	76.25	55.00	51.25	Y = 61.25	20.94
Standing	70.00	36.25	45.00	56.25	Y = 51.87	26.68
Lying	136.25	136.25	183.75	143.75	[3]	11.94
Drinking water	2.50	0.00	2.50	2.50	Y = 1.87	203.67
Other	16.25	13.75	15.00	17.50	Y = 15.62	96.88
			Dawn			
Feeding	5.00	3.75	1.25	2.50	Y = 3.12	103.28
Ruminating while standing	10.00	10.00	13.75	2.50	Y = 9.06	95.22
Ruminating while lying	148.75	150.00	148.75	155.00	Y = 150.62	18.55
Standing	21.25	18.75	11.25	22.50	Y = 18.43	47.45
Lying	161.25	165.00	170.00	157.50	Y = 163.43	20.59
Drinking water	0.00	0.00	0.00	2.50	Y = 0.62	400.00
Other	8.75	7.50	8.75	12.50	Y = 9.37	43.54

[1]Intake of PFP in relation to dry matter intake (DMI), [2]$Y = 61{,}25 + 25{,}7776x - 8{,}33517x^2 + 0{,}632378x^3$, [3]$Y = 126{,}849 + 18{,}7127x - 1{,}84052x^2$. *P>0.05*.

TABLE 6 - Average climatic variables of the experiment per period.

	Period			
	Morning	Afternoon	Night	Dawn
Room temperature	28.3	30.8	27.8	30.1
Dry-bulb temperature	31	33	26	30
Wet-bulb temperature	27	27	24	26

The addition of PFP to the diet of the sheep did not significantly influence the FBT in the morning (Table 7), with an average value of 32.46°C. Likewise, no significant difference was observed for RBT, which had an average value of 32.03°C. The addition of different levels of PFP in animal feed did not change the RT (35.96°C), which, according to Cunninghan (2008), was close to normal for sheep, which is between 38.5°C and 39.5°C. Furthermore, there was no influence from the addition of PFP on RR, with an average value of 50.70 movements min^{-1}. Reece (1996) stated that the normal range of RR for sheep is 16 to 34 movements min^{-1}, which is below the average obtained in the present study. This probably occurred because of the ambient temperature at the experimental site, which increased the RR to obtain homeostasis.

Regarding THI, an average of 77.71 was obtained and occurred because of the high temperature at the experimental site through DBT and WBT (Table 6). According to the classification proposed by Souza et al. (2010), a level of THI that is between the range of $74 \leq HI < 79$ indicates a hot environment, where thermal discomfort starts, which can cause health problems and reduced animal performance.

TABLE 7 - Physiological parameters of sheep receiving diets with addition of PFP, in the morning period (7 and 11 h).

	PFP (%DMI[1])				Regression	P	CV (%)[2]
	0%	1.6%	5.8%	8.9%			
Front body temperature	31.86	32.02	32.67	33.29	Y = 32.46	>0.05	7.93
Rear body temperature	31.27	31.90	32.57	32.36	Y = 32.03	>0.05	8.93
Rectal temperature	36.20	35.43	36.25	35.95	Y = 35.96	>0.05	6.53
Respiratory rate	54.82	51.08	49.08	47.81	Y = 50.70	>0.05	33.44
THI	77.71	77.71	77.71	77.71	Y = 77.71	>0.05	6.16

[1]Intake of PFP in relation to dry matter intake (DMI). [2]CV = coefficient of variation. P>0.05

In the afternoon, there was no significant difference (Table 8) in the variables studied with the inclusion of the PFP, and the values are in agreement with those in the literature. However, a THI with an average of 82.33 indicated the animals were probably under thermal stress. According to the classification by Souza et al. (2010), a THI that is classified in the range of 79 ≤ THI < 84 indicates a very hot environment, which may be dangerous with very serious health consequences, presenting the need to take precautions to avoid losses in production. The value obtained for THI is caused by the high temperature in the afternoon, with an average of 31°C reaching a maximum of 34.3°C.

TABLE 8 - Physiological parameters of sheep receiving diets with addition of PFP, in the afternoon period (13 and 17 h).

	PFP (%DMI[1])				Regression	P	CV (%)[2]
	0%	1.6%	5.8%	8.9%			
Front body temperature	33.27	34.04	33.93	33.95	Y = 33.80	>0.05	6.39
Rear body temperature	33.02	33.64	33.29	33.18	Y = 33.28	>0.05	5.08
Rectal temperature	37.62	36.86	37.88	37.92	Y = 37.57	>0.05	4.19
Respiratory rate	61.81	68.92	62.42	61.91	Y = 63.76	>0.05	17.18
THI	82.34	82.28	82.34	82.34	Y = 82.33	>0.05	5.34

[1]Intake of PFP in relation to dry matter intake (DMI). [2]CV = coefficient of variation. *P>0.05*.

The RR values of 50.70 (Table 7) and 63.76 (Table 8) movements min^{-1} obtained in the present study in the morning and afternoon periods, respectively, were slightly different from the values obtained by Amaral et al. (2009), who studied the effects of dietary supplementation on the physiological responses in Santa Inês, Ile de France, and Texel sheep. The authors divided the animals into two treatments, with RR values of 42.27, 81.71, and 63.20 for Santa Inês, Ile de France, and Texel in the morning period, respectively. In the afternoon, RR was 58.97, 132.73 and 106.94 for Santa Inês, Ile de France, and Texel, respectively, and the values were different from those found in the present study. This may have occurred because the animals were housed in a covered metabolism sector, whereas the animals of the aforementioned study were in an open environment.

By analyzing the average of the 4 h (0700, 1100, 1300, and 1700 h) in which the data were collected, we obtained the averages that are expressed in Table 9. The THI value with an average of 80.02 indicated a very hot value for animals caused by the high values of DBT and WBT, which were used to calculate the THI according to the method proposed by Thom (1959). In the present study, the values of DBT and WBT are shown in Table 6 and are higher values than those found in the literature. This probably increased the ITU, with an average of 80.02 (Table 9), causing a dangerous level for the animals.

TABLE 9 - Physiological parameters of sheep receiving diets with addition of PFP, in the diurnal period.

	PFP (%DMI[1])				Regression	P	CV(%)[2]
	0%	1.6%	5.8%	8.9%			
Front body temperature	32.56	33.03	33.30	33.62	Y = 33.13	>0.05	5.72
Rear body temperature	32.15	32.77	32.93	32.77	Y = 32.66	>0.05	4.55
Rectal temperature	36.91	36.15	37.06	36.94	Y = 36.76	>0.05	3.81
Respiratory rate	58.50	59.75	55.75	55.00	Y = 57.25	>0.05	14.54
THI	80.02	79.99	80.02	80.02	Y = 80.02	>0.05	3.72

[1]Intake of PFP in relation to dry matter intake (DMI). [2]CV = coefficient of variation. P>0.05

CONCLUSIONS

The addition of PFP to sheep feed did not alter DM and nutrient intake. The PFP did not change the ingestive behavior of the sheep in the early morning, morning, or afternoon. However, an increase in the feed intake time and leisure time during the night was observed. It was assumed that such behavior was caused by the milder temperature during this period, which stimulated a greater intake of feed by the animals.

The PFP did not influence any of the physiological variables; however, the elevated temperature during the execution of the experiment probably influenced animal performance, causing discomfort and changes in their ingestive behavior.

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