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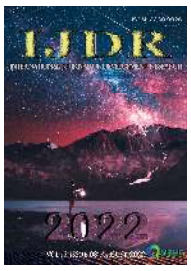

RESEARCH ARTICLE OPEN ACCESS

INGESTIVE BEHAVIOR OF DAIRY HEIFERS RECEIVING PASSION FRUIT PEEL SILAGE *IN NATURA* WITH PASSION FRUIT PEEL DEHYDRATED AS AN ADDITIVE

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ABSTRACT

The objective was to evaluate the ingestive behavior of dairy heifers confined and fed with passion fruit pell silage *in natura* with inclusion levels of dehydrated and concentrated passion fruit peel. The treatments consisted of 6 different silages, being: passion fruit silages with 0, 7, 14, 21, 28 and 35% inclusion of dehydrated passion fruit peel. Six dairy heifers distributed in a Latin square (6x6) were used. The data were submitted to the normality test (Shapiro-Wilk test), analysis of variance, polynomial contrasts and regressions, in SAS at 5% significance. No differences were observed for feeding, idle and water intake times, in addition to the number and time of chewing per bolus and the feeding efficiencies of dry matter and neutral detergent fiber. Rumination time and number of chewed boluses showed linear reductions. The rumination efficiencies showed increasing linear values according to the increase in the level of inclusion of the additive. The use of passion fruit residue silage with up to 35% inclusion of dehydrated passion fruit peel did not interfere negatively in the behavior of the animals, presenting itself as a good option in the feeding of dairy heifers.

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INTRODUCTION

Fruit residues have increased with the expansion of fruit agro-industries, generating an increase in operating costs for industries and greater concerns about their disposal, as they are a potential environmental polluter when disposed of inappropriately. This situation is worrying, given the increase in the cost of agro-industrial production, the possible undesirable environmental impacts and the destruction of a possible food source (Nascimento Filho; Franco, 2015).

Faced with the need to add value to these residues, there was an opportunity to use them in animal feed. Some studies have demonstrated the potential of fruity residues for animal feed, both in tredm of nutrition, reduction in the cost of animal production and mitigation of possible environmental problems arising from their improper disposal (Vieira *et al.*, 2017). Among the various fruit residues, passion fruit (*Passiflora* sp) has been highlighted, due to its bromatological characteristic and its post-processing residual amount (Neiva Junior, 2005), being composed of the peel and seeds, which make up approximately 65 to 70% of the total fruit (Silva, 2015).

Although the passion fruit agro-industrial residue has the potential to make the nutritional plan viable and also reduce the costs of the diet, its inclusion in animal feed still has some obstacles in relation to operational management, which make its greater use difficult. As an alternative to facilitate the operationalization of its use, conservation methods can be used, such as silage of the material, which, through the fermentation process, allows food storage for a long period for later use and prevents deterioration. It is also an efficient food strategy (Diniz *et al*., 2018). The reflection of the response to handling and the quality of the diet can be evaluated by the ingestive behavior of the animals, due to the dietary selection of cattle being affected by the physical and chemical characteristics of the food, with a significant weight on the acceptance of the product (Moreira *et al*., 2014; Fernandes *et al*., 2017). Being of paramount importance to know the composition of the residue and the relation residue x diet x animal, through the ingestive behavior in relation to the diverse possibilities of inclusion in the diet. Due to the use of passion fruit residue being presented as a good option in animal feeding, but still having little knowledge about its characteristics and forms of use, mainly about its silage and acceptance by animals, the objective of this research was to evaluate the ingestive behavior of confined dairy heifers fed with passion fruit residue silage with different levels of dehydrated passion fruit inclusion.

METHODOLOGY

The research project was approved by the Ethics Committee on the Use of Animals - CEUA of the Federal University of Rondônia, under protocol 009/2021. The experiment included the evaluation of a diet composed of six silages of passion fruit residue (peel) *in natura* with inclusion levels (0, 7, 14, 21, 28 and 35%) of dehydrated and crushed passion fruit peel additive, with based on natural matter, in addition to the concentrate, which was the same for all treatments. For the preparation of the silage, the passion fruit residue was previously dried and crushed as an additive, for subsequent silage of the raw materials. The residue, as it came from the agro-industry, was spread in layers of approximately 7 cm thick in an uncovered cemented area, for dehydration in the sun, until they reached a moisture content lower than 15%. After drying the peels, they were ground in a mill (DPM-1, Nogueira®) and a 5 mm sieve, and stored for later incorporation during ensiling. With the two types of passion fruit residue available: *in natura* (peel of the fruit recently processed in the agro-industry) as the main material and of larger size (peel of the fruit cut in half); and the dehydrated and crushed as the additive and smaller particles. The silages were prepared according to the inclusion levels (0, 7, 14, 21, 28 and 35%) of each treatment. The silos, 200 liter drums lined with plastic bags, were filled, little by little, with small portions of the homogenized materials and compacted with the pressure of the body through trampling. Fifteen silos were made for each treatment. After filling and compacting, the silos were closed with plastic clamps, identified and stored at room temperature and protected from sunlight and rain. The minimum fermentation period was 30 days.

After this period, the opening of the silos occurred according to the need for the supply and consumption of silage by the animals, for the respective treatment. Samples of food provided and leftovers were collected throughout the evaluation period and dried in an oven at 55ºC for 72 h to determine the partially dry matter and then ground in a Willey mill, with a 1mm sieve. The MS was determined in an oven at 105ºC for 24 hours (Silva; Queiroz, 2002). The determination of neutral detergent fiber (DNF) was carried out in polyester bags (Komarek, 1993). Dry matter intake (DMI) and neutral detergent fiber intake (DNFI) were measured by the feed minus the leftovers from the diet. The diets (Table 1) were composed of 50% forage, being the passion fruit residue silages, according to the treatments, and 50% of concentrate, based on the DM. The concentrate was composed of 45% broken corn; 25% crushed cupuaçu seed; 25% DDG (Dried distillers Grains – Distillery Dry Grains); 2% livestock urea; and 3% mineral salt, according to manufacturer's warranty levels. Ingestive behavior parameters of 6 dairy heifers were evaluated in relation to the food provided. The animals were crossbred, with a mean age of 9 ± 1 months and an initial mean weight of 133.16 ± 20.7 kg, which were identified, previously treated against ectoparasites and endoparasites, and separated into individual pens of 16 m², containing partitions of wood, concrete floor covered with shavings, trough and individual drinking fountains. The experiment consisted of six periods, each lasting 14 days, with 12 days of adaptation and 2 days of data and sample collection, totaling 84 days. Food was supplied twice a day (morning and afternoon) and water was available *ad libidum*in automatic drinking fountains. During the experimental period, daily weighing of food provided and leftovers were performed. The evaluation of the animals' ingestive behavior was performed for 48 consecutive hours, for each period. Visual observation of the animals took place every 5 minutes marked on a stopwatch, by two observers strategically positioned in a relay system, with an 8-hour shift. Feeding time, water intake, idleness and rumination activity were evaluated, in addition to the number and time of chews per bolus. During each shift, 4 evaluations were collected to determine the number and time of ruminations per bolus (adapted from Bürger *et al*., 2000). The number of boluses chewed (NBC) daily was obtained by dividing the total rumination time by the average time spent ruminating a bolus. Feeding efficiency as a function of DMI (FEDM) and rumination efficiency as a function of DMI (REDM) were obtained by dividing the DMI (kg) by feeding time (h) and rumination time (h), respectively. Feeding efficiency as a function of DNFI (FEFFI) and rumination efficiency as a function of CNDF (REDM) were obtained by dividing DNFI (kg) by feeding time (h) and rumination time (h), respectively (Bürger*et al*., 2000). The experimental design used to evaluate the ingestive behavior of the animals was the 6x6 Latin square, with one animal/treatment/period and rotation of the treatment per animal per evaluation period. The data were submitted to the normality test (Shapiro -Wilk test), analysis of variance, polynomial contrasts and regressions (linear, squared and cubic), using the SAS statistical package, at a 5% significance level.

RESULTS AND DISCUSSION

Feeding time (FT), idle time (IT) and time ingesting water (TIW) were not influenced (P>0.05) by the different inclusion levels, with an average of 3.69, 17.6 and 0, 19 hours respectively. In the rumination time (RT) there was a difference (P<0.05) between the diets, showing a linear reduction according to the increase in the levels of inclusion of the additive (Table 2). The daily activity rhythm of a bovine is characterized by alternating phases between feeding, idleness, rumination and water intake (Fernandes *et al*., 2017), which can be affected by a number of factors (Ribeiro *et al*., 2011). The physical and chemical characteristics of the food, as well as the animal's previous experience, considerably interfere in the level of dietary selection of cattle (Fernandes *et al*., 2017). Thus, ingestive behavior is an important tool in the evaluation of diets and their relationship with animal performance (Goularte *et al*., 2011), as it reflects the animals' response to management and the quality of the diet (Moreira *et al*., 2014). The time spent by heifers for feeding (feed intake) was not affected by the different silages, even though they had different proportions of DM in their composition according to the increase in additive, but it reflected in differences in consumption and as a consequence showed a difference in feeding efficiency. Possibly, the capture of smaller particles from silages with higher levels of additive inclusion must have facilitated the ingestion, requiring less time to consume the same amount of DM in less kg of natural matter of the silages, resulting in greater consumption at the same AT. The idle period varies between 9 and 12 hours a day (Fraser, 1980; Orr *et al*., 2001; Phillips; Rind, 2001). In general, heifers spent little time eating, ingesting water and ruminating, which was reflected in the IT. Despite not having shown significant differences in IT, a long time spent in idleness can be observed. The longer the time devoted to leisure, that is, to rest, the lower the energy expenditure by animals for physical activities, which contributes to increased animal performance due to the lower energy requirement for maintenance (Missio *et al*., 2010).

Table 1. Bromatological composition of the concentrate, passion fruit residue silages with different levels of additive inclusion, of the diets (50% of silage and 50% of concentrate, based on dry matter) used in animal feed, in addition to the consumption of dry matter and neutral detergent fiber

COMPONENTS	DM, %	MM, %	CP, %	EE, %	NDF, %	NFC, %
Concentrate	90.29	6.45	21.77	19.59	24.00	28.19
Silage 0%	12.18	9.05	10.60	2.45	55.46	22.43
Silage 7%	18.82	9.45	11.40	2.29	56.01	20.84
Silage 14%	23.97	11.47	11.41	1.90	56.88	18.34
Silage 21%	28.13	11.50	11.17	1.59	59.20	16.54
Silage 28%	31.81	11.24	11.28	1.57	58.83	17.07
Silage 35%	36.67	11.00	10.98	1.46	57.34	19.25
Diet: 0% additive	51.24	7.75	16.19	11.02	39.73	25.31
Diet: 7% additive	54.56	7.95	16.59	10.94	40.00	24.51
Diet: 14% additive	57.13	8.96	16.59	10.74	40.44	23.27
Diet: 21% additive	59.21	8.97	16.47	10.59	41.60	22.36
Diet: 28% additive	61.05	8.84	16.53	10.58	41.42	22.63
Diet: 35% additive	63.48	8.72	16.36	10.53	40.67	23.72
DMI	3.56	5.40	5.23	5.51	5.74	5.70
DNFI	1.39	2.13	2.11	2.46	2.36	2.27

MS: dry matter; MM: mineral matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; CFN: non-fibrous carbohydrate; DMI: dry matter intake; DDFI: neutral detergent fiber intake.

Table 2. Ingestive behavior of dairy heifers fed with fresh passion fruit peel silage with levels of dehydrated passion fruit peel as additive

Variables	Passion fruit peel additive levels, %						Average	CV, %	Regression		
	0	7	14	21	28	35			L	Q	Ç
FT, h	3.63	3.68	3.52	3.88	3.56	3.90	3.69	13.6	*	*	*
IT, h	17.0	17.5	17.5	17.2	18.2	17.9	17.6	4.70	*	*	*
RT, hr	3.18	2.63	2.81	2.71	2.09	2.04	-	22.1	**	**	**
TWI, h	0.14	0.19	0.19	0.22	0.19	0.18	0.19	55.5	*	*	*
FEDM	1.01	1.51	1.46	1.45	1.64	1.52	1.44	24.4	*	*	*
REDM	1.17	2.26	1.84	2.02	2.86	2.98	-	27.7	**	**	**
FEFND	0.39	0.59	0.58	0.64	0.67	0.60	0.59	25.3	*	*	*
REFND	0.46	0.88	0.72	0.89	1.15	1.19	-	28.6	**	**	**
NCB	33.5	34.7	37.6	36.1	37.1	41.0	36.7	17.5	*	*	*
TBC	33.7	36.0	38.4	37.7	38.6	41.8	37.8	12.8	*	*	*
NBC	341.6	256.7	274.0	263.9	197.1	178.2	-	22.7	**	**	**

*P>0.05; **P<0.05; CV = coefficient of variation; L = linear; Q = quadratic; C = cubic; TA = feeding time; IT = idle time; RT = rumination time; TWI = time of water intake; FEDM = feed efficiency as a function of dry matter intake, g MS kg $^{-1}$; REDM = rumination efficiency as a function of dry matter intake, g MS kg $^{-1;}$ FEFND = feed efficiency as a function of neutral detergent fiber consumption, g MS kg $^{-1}$; REFND = rumination efficiency as a function of neutral detergent fiber consumption, g MS kg $^{-1}$; NCB = number of chews per bolus, number; TBC = chewing time per bolus, second; NBC = number of bolus chewed, number. Equations: TR = 0.17191-0.00083023X (R^2 = 0.15); REDM = 1.11774 + 0.30911 (R^2= 0.39); REFND = 0.43571 + 0.13008 (R^2= 0.39); NBC = 322.02896-4.03851X (R^2 = 0.24).

The duration and distribution patterns of rumination cycles are influenced by ingestion activities, the physical form of the diet, the cell wall content of roughage, feeding frequencies, and the quantity and quality of food consumed (Murphy *et al*., 1983, Van Soest, 1994; Dado; Allen, 1995). Possibly the RT was influenced by the different proportions of particle sizes between the silages, where the additive consisted of particles close to 0.5 cm and as its inclusion increased, there was an increase in these smaller particles and a reduction in larger particles (*in natura* passion fruit peel), depending on lower return activity for re-chewing and consequently reducing the time spent in rumination. Because physical characteristics of the diet, such as particle size considerably influence rumination (França *et al*., 2009). The FEDM and FEFFI did not differ (P>0.05), possibly due to the close relationship between FT and DMI and DNFI. REDM and ERFDN, on the other hand, showed linear increases according to the inclusion of the additive (Table 2), with an increase of 0.39 g MS/kg and 0.39 g NDF/kg for each 1% of additive inclusion. Possibly the increase in rumination efficiencies were influenced by the interaction of the higher DMI and DNFI and the lower time spent in rumination according to the addition of dehydrated passion fruit peel. Furthermore, the rumination efficiency of the food is positively affected by the elevation of DM in the diet (Silva *et al*., 2005). Evaluating the replacement of Tifton 85 grass hay (*Cynodon*sp) by the co-product of dehydrated passion fruit (without crushing) at different inclusion levels (0, 12, 24, 36% of DM) in the diets of dairy heifers, Figueredo (2015) did not observe differences in the average times spent with feeding (5.52 h/day), idleness (9.01 h/day) and rumination (8.53 h/day), nor on feeding efficiencies, rumination efficiency, bolus chews and bolus chewing time (BCT), with mean values of 1.35; 0.867; 11.2 and 42.13, respectively. This difference observed when compared with that of the present research, possibly occurred due to the differences in the chemical and physical characteristics of the evaluated foods, because the more fibrous the foods, the longer are the periods spent with ingestive activities that demand energy. Rumination efficiency is an important factor in roughage feeding, as rumination of a greater amount of roughage in a given period of time provides greater consumption and theoretically greater productivity (Pazdiora *et al*., 2011).

NBC and TBC showed no differences (P>0.05) between the diets (Table 2), possibly due to the similarity in their compositions, mainly in relation to the proportion of NDF and non-fibrous carbohydrate (NFC) (Pazdiora *et al*., 2011; Arguenta*et al*., 2019). For the NBC, there was a linear reduction according to the inclusion of the additive, with a decrease of 4.03 cakes for each 1% of inclusion of the additive (Table 2). Possibly the reduction in NBC was due to the lower need to return the food for re-chewing associated with the smaller particle size, also due to its direct relationship with the RT (Arguenta *et al*., 2019), which showed a reduction, and the time spent to ruminate each bolus, which showed no interference. The NRC (2001) recognizes the importance of forage particle size in the chewing stimulation, saliva secretion and stability of rumen function.

CONCLUSION

The inclusion level of up to 35% of dehydrated and crushed passion fruit in the silage of fresh passion fruit peel *in natura* does not interfere negatively in the ingestive behavior of confined dairy heifers. The inclusion of dehydrated peel provides, under the conditions evaluated, an increase in feeding and rumination efficiency as a function of the consumption of dry matter and neutral detergent fiber. The use of passion fruit residue silage at levels 0, 7, 14, 21, 28 and 35% inclusion of dehydrated passion fruit peel presents itself as a good option in the feeding of dairy heifers, in the growing phase.

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