Ciências Agrárias
SEMINA

DOI: 10.5433/1679-0359.2022v43n6p2755

Economic viability of different diets for F1 Holstein x Zebu cows in milk production systems

Viabilidade econômica do uso de diferentes ofertas de dietas para vacas F1 Holandês x Zebu no sistema de produção de leite

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Highlights

Feed restriction led to a reduction in the total dry matter intake.
Feed restriction modified milk production in crossbred cows.
Feed restriction up to 2.00% BW did not change the activity profitability.

Abstract

The aim of this study was to evaluate different levels of feed restriction in the diet for F1 Holstein x Zebu cows during the winter on performance and economic viability. Data from Zootechnical book keeping, and from experiments conducted in the Experimental Field of Felixlândia, belonging to EPAMIG, were used. Total lactation of sixty F1 Holstein x Zebu cows receiving different diets was analyzed, by 2.00%, 2.25%, 2.50%, 2.75% body weight (BW), and a control group (3.4%; no feed restriction), allowing 5% leftovers in relation to the dry matter supplied, distributed in a completely randomized design. Data on milk production and feed cost were collected, evaluating the different periods that characterize the lactation of an animal. The highest milk production was found in the diet levels 3.4 %, and 2.75% BW, 3,636.00, and 3,271.50 kg, respectively. Lower milk production was observed at levels of 2.50%; 2.25%; 2.00% BW, respectively. The highest feed cost was verified without feed restriction followed by the levels of 2.75%, 2.50%, 2.25%, and 2.00% BW. The supply of the no feed restriction diet resulted in a performance superior to levels 2.75; 2.50; 2.25; 2.00% BW. The items profit, profitability were similar between all treatments, indicating that, when there is occasional feed shortage, a restriction in the diet supply of up to 2% BW provides economic

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Received: Apr. 02, 2022 - Approved: Jan. 06, 2023

security to the rural producer.
Key words: Production cost. Profitability. Feed restriction. Crossbred cows.

Resumo

Objetivou-se por meio deste estudo avaliar diferentes níveis de restrição alimentar da dieta de vacas F1 Holandês x Zebu durante o inverno sobre o desempenho e viabilidade econômica. Foram utilizados dados da escrituração zootécnica e de experimentos realizados no Campo Experimental de Felixlândia, pertencente à EPAMIG. Foi analisada a lactação total de sessenta vacas F1 Holandês x Zebu submetidas a diferentes ofertas de dieta, em 2,00%, 2,25%, 2,50%, 2,75% do peso corporal (PC) e um grupo controle com alimentação à vontade (3,4%), permitindo 5% de sobras em relação à matéria seca fornecida, distribuídos em delineamento inteiramente casualizado. Os dados de produção de leite e custo alimentar foram coletados, avaliando os diferentes períodos que caracterizam a lactação de um animal. A maior produção de leite foi verificada nos níveis de dieta 3.4% e 2,75% PC, sendo 3.636,00 e 3.271,50 kg, respectivamente. Produção de leite inferiores foram verificadas nos níveis de 2,50%; 2,25%; 2,00% do PC. O maior custo com alimentação foi verificado no nível de alimentação à vontade seguido dos níveis de 2,75%; 2,50%, 2,25% e 2,00% do PC. A oferta da dieta sem restrição teve um rendimento superior aos respectivos 2,75 níveis; 2,50; 2,25; 2,00% do PC, respectivamente. Os itens lucro, lucratividade e rentabilidade foram semelhantes entre todos os tratamentos, demonstrando que, quando há escassez eventual de alimento, a restrição no fornecimento da dieta de até 2% do PC oferece segurança econômica ao produtor rural que utiliza vacas em seu sistema F1 Holandês x Zebu.
Palavras-chave: Custo de produção. Rentabilidade. Restrição alimentar. Vacas mestiças.

Introduction

In Brazil, milk yield is mostly characterized by extensive systems in the summer, and intensive in the winter, with large fluctuations in productivity during the year, mainly in the winter, due to the seasonality of forage production (Souza et al., 2022; Da Hora et al., 2023). Thus, it can be inferred that cows kept in an extensive system are subjected to some type of feed restriction during a certain period of lactation. However, it is not known to what extent this practice interferes with milk yield.

The search for greater productivity and sustainability has caused profitability dairy farming to undergo several technological changes over the years. In this way, crosses between Zebu and taurine breeds increased, giving rise to the F1 animal, which has favorable characteristics for milk yield in tropical regions, such as rusticity, adaptability and longevity (Ruas et al., 2011).

Another advantage of this group of animals is the diversity of the final products: milk and meat (Ruas et al., 2011), which places the activity in a prominent position compared to other production systems that prioritize the exclusive production of milk. The yield of milk and meat guarantees the producer greater economic and commercial balance (Ferreira et al., 2010).

Although crossbred animals are commonly known to have good adaptability to tropical conditions, data in the literature

regarding tolerance levels in situations of reduced dietary supply are recent.

Studies evaluating feed efficiency of F1 Holstein x Zebu cows on different levels of diet supply have shown promising results, such as improvement in feed efficiency, and maintenance of milk yield, showing the productive potential of this breed composition, in the face of new feeding technologies (Monção et al., 2019; Santana et al., 2019; Borges et al., 2020; Da Hora et al., 2023).

However, results of economic efficiency of diet supply restriction in F1 Holstein x Zebu cows are scarce in the literature.

Given the above, this study aimed to evaluate the economic viability and impact on profitability of different levels of diet supply in F1 Holstein x Zebu cows during the winter.

Material and Methods

All procedures involving animals were approved by the Animal Ethics Committee of Unimontes (CEEBEA) under protocol 129 - 2016.

Data from zootechnical bookkeeping and from experiments conducted in the Experimental Field of Felixlândia belonging to EPAMIG, located in Felixlândia, state of Minas Gerais, were used. The climate is classified as tropical savanna, with two distinct seasons: dry winter (May to October) and rainy summer (November to April). The average annual rainfall is 1,171 mm, the average annual temperature is 22.9°C (Dados Climáticos para Cidades Mundiais, 2020).

Data evaluated here came from results of experiments evaluating the effect of feed restriction on productive, physiological and metabolic parameters of F1 Holstein x Zebu cows (Borges et al., 2020). And production cost data, generated from the database of the same herd and published by Martins et al. (2018).

The cost of milk yield of sixty F1 Holstein x Zebu cows with an average body weight (BW) of 482.2 ± 35 kg and an average of 4.5 calving was evaluated. These were subjected to a feeding management with different levels of diet supply, equivalent to 2.00; 2.25; 2.50; 2.75% BW and a control group with ad libitum feeding, equivalent to 3.4% BW, allowing 5% leftovers in relation to the dry matter supplied ad libitum. The diet consisted of 75% corn silage, and 25% commercial supplement containing 22% crude protein, and 70% TDN, as published by (Borges et al., 2020). Nutritional and milking management is described in Borges et al. (2020).

The effects of different levels of diet supply on the productive and economic performance of cows were evaluated. For productive performance, the following data were considered: total milk yield, liters of milk per kilogram of concentrate ratio, average weight of cows and calves, total intake of dry matter, silage, and concentrate. In the evaluation of economic performance, data considered were: costs, revenues, profit, profitability.

To assess the cost of milk yield in the different treatments tested, the operating cost common to all cows, individual operating cost, depreciation cost of animals and machines, opportunity cost and total cost (TC) were determined.

The value of R$973.00 was considered for the common operating cost per cow/lactation, a cost described in detail in Martins et al. (2018). The individual operating cost considered the cost of feeding each cow. The cost of consuming silage and concentrate was obtained by multiplying the amount ingested, determined according to the BW of each cow, by days of lactation and by purchase price. Values per kilogram of the dietary components in the year of evaluation corresponded to R$ 0.17 for corn silage and R$ 1.61 for concentrate.

Depreciation cost was obtained by the difference between the initial price and the final price for discarding the cows, divided by their length of stay in the herd. The initial value was calculated considering the price of the cow market (Centro de Estudos Avançados em Economia Aplicada [CEPEA], 2017) multiplied by a factor, according to the methodology described by Martins et al. (2018). Machine depreciation calculation was performed by decomposing the total price over the useful life of the machine. To obtain the TC, in addition to the operating and depreciation cost, the investment opportunity cost was included, calculated according to the interest rate set by the Central Bank.

Cost values obtained were used to evaluate the economic efficiency of the technology considering the revenue values, from the sale of milk and calf. The revenue from the sale of milk was obtained by calculating the estimated milk production in 270 days of lactation, multiplied by the average price (R$ 1.12) paid for the liter of milk in the year in which the data were collected. To obtain the calculation of the calf revenue, the estimated weight of the calf at 270 days was considered, multiplied by the average price paid for the arroba (R$ 225.62) in the year of assessment.

The experimental design used was completely randomized. Data were subjected to analysis of variance (ANOVA) using the SISVAR 5.6 software, when significant differences were detected and in the absence of interactions, the means were compared using the Scott-Knott test at 5% probability.

The percentage of reduction in feed intake, milk production, and economic analysis were estimated, seeking to detect reductions in these variables as a result of different levels of diet supply.

Results and Discussion

The results obtained from total milk production, as well as feed intake, were estimated considering the lactation periods, based on data obtained by Borges et al. (2020). For calculation purposes, lactation lasting 270 d was considered, and each period represented the production of 90 days.

Similarity (P>0.05) was found for total milk yield of cows receiving the diet comprising 2.75% and 3.40% BW, demonstrating that a reduction of up to 19% in the diet supply did not change production of milk by F1 Holstein x Zebu cows (Table 1).

Table 1
Productive performance of F1 Holstein x Zebu cows according to the level of diet supply

Diet supply (% BW)	Total milk yield (kg)	[4]Var.	[1] Liters of milk per kilo concentrate	[3]Var.	Average cow weight during lactation (kg)	[3]Var.	[2] Calf weight (kg)	[3]Var.
3.40*	3.636.00 A ±366.86	0	2.96 C ±0.24	0	499.66 A ±30.51	0	166.61 A ±34.17	0
2.75	3.271.50 A ±429.90	-10.02	3.71 B ±0.56	25.33	457.91 B ±11.14	-8.35	156.22 A ±26.99	-6.23
2.50	3.006.75 B ±191.97	-17.30	3.67 B ±0.25	23.98	467.08 B ±27.14	-6.52	158.87 A ±17.10	-4.64
2.25	3.005.25 B ±159.95	-17.34	4.30 A ±0.26	45.27	442.16 B ±12.52	-11.50	161.69 A ±17.26	-2.95
2.00	2.693.25 B ±311.92	-25.92	4.19 A ±0.52	41.55	457.91 B ±11.31	-8.35	176.40 A ±25.63	5.87
[3]CV (%)	9.91		10.55			4.38	15.29	

Means followed by different letters, in the same column, are significantly different (P>0.05) by the Scott-Knott test.
[1] Ratio of liters of milk per kilo of concentrate in lactation;
[2] Estimated body weight of calf at weaning 270 d (kg);
[3] Coefficient of variation;
* dry matter intake;
[4] Var- Variation (%).

Supply levels of 2.5; 2.25 and 2.00% BW had similar averages (P>0.05) (3,006.75; 3,005.25; 2,693.25 kg), higher than the national average productivity of 2,141 kg (Instituto Brasileiro de Geografia e Estatística [IBGE], 2019).

Cows receiving a diet on the basis of 2.00% BW produced 41.37% more milk per kilogram of concentrate consumed, compared to cows that received a diet equivalent to 3.40% BW.

Cows that received the nutritional plan at will had higher BW (P<0.05), 499.66 kg, compared to the levels of diet supply with feed restriction, which had an average of 456.26 kg. There was no significant difference (P>0.05) in the estimated weight (163.95 kg) of calves at weaning according to the diet supply (Table 1).

The total dry matter intake in lactation, total silage intake, and concentrate decreased (P<0.05) as the feed restriction increased the profitability owed similarity (P>0.05) between the 2.25%, and 2.00% BW levels (Table 2).

Table 2
Means of feed intake characteristics of F1 Holstein x Zebu cows according to the level of diet supply

Diet supply (% BW)	Total dry matter intake in lactation (kg)	Variation	Total silage intake of natural matter (kg)	Variation	Total intake concentrate of natural matter (kg)	Variation
3.40*	4.721.85A ±288.33	0	7.044.73A ±430.18	0	1.227.09A ±74.93	0
2.75	3.400.03B ±82.76	-27.99	5.072.66B ±123.48	-27.99	883.58B ±21.50	-27.99
2.50	3.152.81C ±183.24	-33.22	4.703.81C ±273.39	-33.22	819.33C ±47.62	-33.22
2.25	2.686.16D ±76.06	-43.11	4.007.60D ±113.48	-43.11	698.06D ±19.76	-43.11
2.00	2.472.75D ±61.1	-47.63	3.689.20D ±91.18	-47.63	642.60D ±15.88	-47.63
[1]CV (%)	4.96		4.96		4.96	

Means followed by different letters, in the same column, are significantly different (P>0.05) by the Scott-Knott test.
Variation (%)
[1] Coefficient of variation; BW - Body weight; * Dry matter intake.

For the individual operating cost (Table 3), the control treatment presented the highest cost (P<0.05), followed by treatments with restriction in the diet supply of 2.75, 2.5%, 2.25, and 2.00% BW, which had lower costs.

Table 3
Feeding cost of F1 Holstein x Zebu cows according to the level of diet supply

Diet supply (% BW)	Individual operating cost (R$)	[2]Var.	Depreciation cost (R$)	[2]Var.	Opportunity cost (R$)	[2]Var.	Total cost (R$)	2Var.
3.40*	2.292.08 A 39.96	0	419.37 A±20.20	0	313.18 A ±13.61	0	3.997.66 A ±173.78	0
2.75	1.659.25 B 40.39	-27.60	391.72 B ±7.38	-6.59	257.04 B ±4.06	-17.92	3.281.04 B ±51.83	-17.92
2.50	1.542.42 B 89.64	-32.70	397.79 B ±17.97	-5.14	247.62 B ±9.14	-20.93	3.160.86 B ±116.77	-20.93
2.25	1.318.09 C 37.32	-42.49	381.29 B ±8.29	-9.08	227.15 C ±3.87	-27.46	2.899.57 C ±49.49	-27.46
2.00	1.217.94 C 30.10	-46.86	391.72 B ±7.49	-6.59	219.52 C ±3.19	-29.90	2.802.22 C ±40.79	-29.90
[1]CV (%)	4.94		3.40		3.11		3.11	

Means followed by different letters, in the same column, are significantly different (P>0.05) by the Scott-Knott test.
Var. - Variation (%)
[1] Coefficient of variation; BW - Body weight; *Dry matter intake; Depreciation Cost of cows and improvements.

The level of control diet supply had a higher (P<0.05) depreciation cost, differing from lower levels of diet supply, which showed similar mean values (P>0.05). Cows receiving the control diet supply level had higher (P<0.05) opportunity cost and total cost, followed by treatments with restriction of 2.75; 2.5%, and 2.25; 2.00 BW, which were similar (P>0.05), respectively.

The control treatment and those with a diet supply of 2.75% BW had higher (P<0.05) milk recipe (R$ 3,868.2), followed by the levels of diet supply of 2.5; 2.25; 2.0% BW that resembled each other, with an average revenue of R$ 3,253.29. The recipe from the sale of calves (R$ 1,233.08) showed no difference (P>0.05) between treatments, however the recipe for milk plus calves (R$ 5,325.33) was superior in the control treatment (Table 4).

Table 4
Economic performance of F1 Holstein x Zebu cows according to the level of diet supply.

Diet supply (% BW)	Milk recipe (R$)	Variation	Calves recipe (R$)	Variation	Total milk plus calves recipe (R$)	Variation
3.40*	4.072.32A ±410.89	0	1.253.01A ±257.03	0	5.325.33A ±402.33	0
2.75	3.664.08A ±481.48	-10.02	1.174.91A ±202.99	-6.23	4.838.99B ±542.86	-9.13
2.50	3.367.56B ±215.01	-17.30	1.194.83A ±128.63	-4.64	4.562.39B ±105.87	-14.32
2.25	3.365.88B ±179.15	-17.34	1.216.02A ±129.83	-2.95	4.581.90B ±237.34	-13.96
2.00	3.016.44B ±349.35	-25.92	1.326.65A ± 192.76	5.87	4.343.09B ±312.92	-18.44
CV (%)	9.91		15.29		7.45	

Means followed by different letters, in the same column, are significantly different (P>0.05) by the Scott-Knott test.
Variation (%)
[1]Coefficient of variation;
BW - Body weight
*Dry matter intake.

For the variables profit, profitability, there was no significant difference (P>0.05) between the levels of diet supply, with an average of R$ 1,502.07, 31.72%, and 47.68%, respectively (Table 5).

Table 5
Economic results of F1 Holstein x Zebu cows according to the level of diet supply

Diet supply (% BW)	Profit (R$)	Variation	Profitability (%)	Variation	Profitability (%)	Variation
3.40*	1.327.67A ±403.44	0	24.64A ±6.25	0	33.33A ±10.24	0
2.75	1.557.95A ±570.25	17.34	31.46A ±8.73	27.67	47.61A ±17.87	42.84
2.50	1.401.52A ±155.81	5.56	30.69A ±2.97	24.55	44.48A ±06.14	33.45
2.25	1.682.34A ±235.83	26.71	36.60A ±3.16	48.53	58.04A ±08.30	74.13
2.00	1.540.87A ±306.03	16.05	35.24A ±4.38	43.01	54.98A ±10.96	64.95
[1]CV (%)	24.21		17.45		23.93	

Means followed by different letters, in the same column, are significantly different (P>0.05) by the Scott-Knott test.
Variation (%)
[1] Coefficient of variation;
BW - Body weight
*Dry matter intake.

The levels of diet supply used were related to milk yield, the higher production observed in the treatment with diet supply of 2.75% BW, and in the control treatment demonstrates the ability of F1 Holstein x Zebu cows to maintain production of milk during lactation, even when the diet supply was reduced by 19.11%.

Thus, feed restriction in F1 Holstein x Zebu cows keeps milk yield at competitive levels in the market, reducing the demand for inputs (feedstock), which has a positive impact on the economic results of the activity.

According to (National Research Council - International [NRC], 2001), deficit in nutrient intake caused by feed restriction can modify the productive performance of animals, since the nutrients are not sufficient for maintenance and production. However, F1 Holstein x Zebu cows in tropical conditions have adaptive characteristics in situations where the diet supply is restricted. They adjust the size of metabolism-related organs to decrease nutritional requirement, and maintain milk yield (Sampaio et al., 2017).

Although the treatments with a greater supply of feed resulted in higher milk yield, when the proportion of milk produced per kilogram of concentrate intake was evaluated, there was a greater proportion of milk yield in cows consuming less concentrated feed.

This can be explained by a possible reduction in the passage of feed, extending its permanence in the gastrointestinal tract of cows, enhancing the use of nutrients (NRC, 2001).

Thus, the restriction in feed supply did not affect milk yield proportional to the amount of nutrients ingested, highlighting the feed efficiency, and productive potential of F1 Holstein x Zebu cows.

Regardless of the level of dietary restriction adopted, cow BW was not altered (2.75; 2.50; 2.25 and 2.00% BW). However, there was a reduction in milk yield, which can be explained by the adaptability of animals with dual ability to maintain body reserves, prioritizing their survival and not compromising reproduction in cases of restriction in feed supply.

Calf weaning weight was not changed according to the nutritional plan the cows were subjected to, because all calves suckled the residual milk after milking. Although the total milk yield showed a difference between the treatments, possibly the cows evaluated had the same milk retention capacity, which may explain the fact that residual milk remained constant. The constancy in the ejection of residual milk may be related to central nervous system regulations, in the voluntary retention of milk to maintain the nutrition of the offspring (Tancin et al., 2001). As milking stimulates the release of prolactin (Negrão & Marnet, 2002), the effect of suckling the calf after the end of mechanical milking may have generated a new stimulus for milk production, and secretion.

The measurement of dry matter intake is important in evaluating feed efficiency, and consequently, in animal production, as it serves as a basis for evaluating the efficiency of utilization of ingested nutrients, and correlating them with possible fluctuations in milk yield (Santana et al., 2019).

Feed restriction led to a reduction in the intake of total dry matter, silage and concentrate, with a reduction of 47.63% in the treatment with greater restriction compared to the control treatment.

However, the total milk yield showed a percent reduction equivalent to 25.92%. This shows the feed efficiency of F1 Holstein x Zebu cows in maintaining good production rates when subjected to feed restriction, tolerating a reduction of up to 47.63% in the supply of feed without significantly altering their productive performance.

The individual operating cost considered the costs with feed (silage and concentrate), showing a reduction of 27.6% in the treatment with 2.75% feed restriction, in relation to the nutritional plan at will, although similarity was observed in the milk yield in the respective treatments, highlighting the fact mentioned above, that F1 Holstein x Zebu cows have high resistance, and adaptation to dietary adversities in milk production systems.

F1 Holstein x Zebu cows had an average cost per liter of milk equivalent to R$ 1.09; BRL 1.00; BRL 1.05; R$ 0.96 and R$ 1.04 for the respective levels of diet supply 3.4%; 2.75%; 2.5%; 2.25% and 2.00% BW.

The cost of depreciation of cows and improvements showed a reduction of 6.58% in relation to control treatment. A cost of improvements of R$ 105.48 common to all cows was considered, according to Martins et al. (2018). The depreciation cost of cows is influenced by the purchase and sale price multiplied by the animal BW, as the cows in the control treatment had higher BW and obtained higher price and depreciation.

The opportunity cost demonstrates how much an economic agent fails to earn from other investments because it decided to use production factors such as land, capital and labor. The higher opportunity cost verified in the control treatment demonstrates the lower profitability of this treatment; despite having higher milk production when the production costs are considered, this treatment does not seem to be the most economically efficient.

The total cost was greatly influenced by the individual operating cost, being higher in the control treatment, intermediate in treatments with restriction of 2.75 and 2.50% BW, and lower in treatments with restriction of 2.25 and 2, 00% BW, showing a reduction equivalent to 29.90% in relation to the control treatment. This shows that although the last three treatments resulted in similar milk yield, the last two treatments required less investment to produce the same amount of milk.

The revenue from the sale of milk followed the pattern of milk yield of the cows, since the recipe is directly related to the quantity and quality of the milk produced.

The revenue value of calves followed their average weight, which did not show any significant difference since they are offspring of cows from the same genetic group, with similar average weight and age.

Revenue from the sale of calves represented 23.53; 24.28; 26.18; 26.53, and 30.34% total revenue for the respective treatments 3.40; 2.75; 2.50; 2.25, and 2.00% BW, corroborating Moraes et al. (2004), who reported revenue from the sale of calves from F1 Holstein x Zebu cows representing about 25% total revenue per year, demonstrating the importance of the sale of calves in determining the profits of the activity.

If the sale of calves was not a task considered within the production process, the profit from the activity would be only R$ 74.60; 383.00; 206.70; 466.30, and 214.20 for the respective levels of diet supply 3.40; 2.75; 2.50; 2.25, and 2.00% BW, based on the difference between the profit obtained from the sale of milk and the total cost. Emphasizing the economic viability of milk production systems with F1 Holstein x Zebu cows, presenting diversity in the final products, which can be strategically used when the commercial market presents fluctuations.

The assessment of costs individually gives us guidance regarding the economic efficiency of the feeding management used, since the cost of feed has a strong influence on the total cost of the activity, however, it is not a parameter for defining profit or loss. The cost and total revenue of the activity must be considered in order to obtain the determining factors in defining the economic viability of any production system, as in most cases, higher cost is associated with higher production (Lopes et al., 2009). The greater total revenue verified in the nutritional plan ad libitum is related to the greater milk yield in this treatment, with a positive balance of 18.44% in relation to the nutritional plan with food restriction. Although the total recipe for the ad libitum treatment was higher than the other levels, its total cost was also higher.

The similarity found between the treatments for the items, profit, profitability demonstrates that the assessment of revenue in a singular way does not always represent the economic performance of the activity. Therefore, when necessary, the milk producer can reduce diet supply without changing profitability.

Conclusions

The reduction in diet supply of up to 2.00% BW for F1 Holstein x Zebu cows reduced milk yield and feed intake, however, it did not change the profitability of the activity.

In times of feed shortage, if necessary, the dairy producer can reduce the supply of the diet by up to 2.00% BW, maintaining the activity profitability.

The production system of F1 Holstein x Zebu cows provides economic security to the producer, even when they are subjected to a reduction in the diet supply of up to 2.00% BW, the sale of calves can represent up to 30% activity profit.

Acknowledgements

The authors would like to thank the Epamig for providing the data, to Finep and MCTI, for financial support to project 1334/13, and Instituto Nacional de Ciência e Tecnologia (INCT - Ciência Animal). Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) for financial support (PPM 00265-18), Universidade Estadual de Montes Claros (Unimontes), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for their assistance with scholarships/research. The authors would like to thank undergraduate students for their contribution towards the accomplishment of the research. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

References

Borges, L. A., Ruas, J. R. M., Rocha, V. R., Jr., Carvalho, C. C. S., Monção, F. P., Gomes, V. M., Rigueira, J. P. S., Pinheiro, P. G. M., Sales, E. C. J., Rufino, L. D. A., Silva, E. A., Queiroz, D. S., & Ferreira, H. C. (2020). Effects of short-term feed restriction on the physiological parameters and metabolites of F1 Holstein x Zebu cows in different stages of lactation. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 72*(4), 1545-1554. doi: 10.1590/1678-4162-11926

Centro de Estudos Avançados em Economia Aplicada (2017). *Boletim do leite.* http://www.cepea.esalq.usp.br/br/indicador/boi-gordo.aspx

Da Hora, F. F., Rocha Júnior, V. R., Monção, F. P., Rigueira, J. P. S., Cordeiro, M. W. S., Caldeira, L. A., Cruz, F. N. F., Alencar, A. M. S., Albuquerque, C. J. B., Leal, D. B., Carvalho, C. C. S., & Costa, M.D. (2023). Nutritional parameters and performance of crossbred heifers fed with millet and BRS716biomasssorghumsilages.*Journal of Applied Animal Research, 51*(1), 74–83. doi: 10.1080/09712119.2022.2155172

Dados Climáticos para Cidades Mundiais (2020). *Felixlândia: Climate-Data.Org.* https://pt.climate-data.org/location/176040

Ferreira, J. J., Ruas, J. R. M., Carvalho, B. C., Silva, E. A., Queiroz, D. S., & Menezes, A. C. (2010). Alimentação do rebanho F1: fator de menor custo na produção de leite. Vacas F1 Holandês x Zebu: produção eficiente de leite. *Informe Agropecuária, 31*(286), 72-80.

Instituto Brasileiro de Geografia e Estatística (2019). *Produção da pecuária municipal 2019.* https://biblioteca.ibge.gov.br/visualizacao/periodicos/84/ppm_2019_v47_br_informativo.pdf

Lopes, M. A., Dias, A. S., Carvalho, F. M., Lima, A. L. R., Cardoso, M. G., & Carmo, E. A. (2009). Resultados econômicos de sistemas de produção de leite com diferentes níveis tecnológicos na região de Lavras, MG nos anos 2004 e 2005. *Ciência e Agrotecnologia, 33*(4), 252-260. doi: 10.1590/S1413-70542009000100035

Martins, T., Neto, Silva, C. B., Ruas, J. R. M., Silva, E. A., Costa, M. D., Gomes, V. M., & Santos, L. H. T. (2018). Viabilidade econômica de vacas leiteiras F1 Holandês x Zebu com diferentes bases maternas e ordens de parto. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 70*(6), 1959-1969. doi: 10.1590/1678-4162-10054

Monção, F. P., Santana, P. F., Rocha, V. R., Jr., Ruas, J. R. M., Rigueira, J. P. S., Borges, L. D. A., Menezes, G. C. C., Sousa, T. E. S., Costa, M. D., Oliveira, L. L. S., & Queiroz, F. E. (2019). Nutritional efficiency of feed-restricted F1 Holstein/Zebu cows in early lactation. *Tropical Animal Health and Production, 52*(1), 141-149. doi: 10.1007/s11250-019-01994-z

Moraes, A. C. A., Coelho, S. G., Ruas, J. R. M., Ribeiro, J. C. V. C., Vieira, F. A. P., & Menezes, A. C. (2004). Estudo técnico e econômico de um sistema de produção de leite com gado mestiço F1 Holandês-Zebu. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 56*(6), 745-749. doi: 10.1590/S0102-09352004 000600008

National Research Council - International [NRC]. 2001. Nutrient requirements of dairy cattle, (7th rev. ed.), National Academies Press, Washington, DC, USA.

Negrão, J. A., & Marnet, P. G. (2002). Effect of calf suckling on oxytocin, prolactin, growth hormone and milk yield in crossbred Gir-Holstein cows during milking. *Reproduction Nutrition Development, 42*(4), 373-380. doi: 10.1051/rnd:2002032

Ruas, J. R. M., Menezes, A. C., Queiroz, D. S., Silva, E. D., & Costa, M. D. (2011). *Cruzamentos para a produção sustentável de leite. EMBRAPA - Pesquisa, desenvolvimento e inovação para a sustentabilidade da bovinocultura leiteira.*

Sampaio, R. L., Resende, F. D., Reis, R. A., Oliveira, I. M., Custódio, L., Fernandes, R. M., Pazdiora, R. D., & Siqueira, G. R. (2017). The nutritional interrelationship between the growing and finishing phases in crossbred cattle raised in a tropical system. *Tropical Animal Health and Production, 49*(1), 1015-1024. doi: 10.1007/s11250-017-1294-8

Santana, P. F., Rocha, V. R., Jr., Ruas, J. R. M., Monção, F. P., Borges, L. A., Rigueira, J. P. S., Ramos, J. C. R., & Gomes, V. M. (2019). Feed restriction of F1 Holstein × Zebu cows in the final third of lactation modifies intake, nutrient digestibility, feeding behavior, and performance. *Revista Brasileira de Zootecnia, 48*(e20180130), 1-10. doi: 10.1590/rbz4820180130

Souza, G. R., Rigueira, J. P. S., Ruas, J. R. M., Gomes, V. M., Rocha, V. R., Jr., Monção, F.

P., Rufino, L. D. A., Carvalho, C. C. S., Silva, A. F., & Silva, E. A. (2022). Supplementation strategies for lactating F1 Holstein x Zebu cows on deferred pastures. *Semina: Ciências Agrárias, 43*(3), 1065-1078. doi: 10.5433/1679-0359.2022v43n3p1065

Tancin, V., Kraetzl, W., Schams, D., & Bruckmaier, R. M. (2001). The effect of conditioning to suckling, milking and of calf presence on release of oxytocin in dairy cows. *Applied Animal Behaviour Science, 72*(3), 235-246. doi: 10.1016/S0168-1591(01)00113-7