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Comparison of dairy production based on feed of *Pennisetum* sp., *Pennisetum purpureum* and CIAT 36087

Comparación de la producción de leche con base en la alimentación con *Pennisetum* sp., *Pennisetum purpureum* y CIAT 36087

Noel Ernesto Blanco–Roa[1]*, Hernaldo Ramón Novoa–Novoa[1], Eveling Cristina Berríos[1], Omar Alfredo Soto–Gutiérrez[1], Carlos Alberto Zúniga–González[1], Silvio Javier Sáenz–Rojas[1], José de Jesús Nuñez–Rodriguez[2]

[1]National Autonomous University of Nicaragua, Leon. Knowledge Area of Agrarian and Veterinary Sciences. Leon, Nicaragua.
[2]University of Santander, Faculty of Economic, Administrative and Accounting Sciences. Cúcuta, Colombia.
**Corresponding author: nblanco@ev.unanleon.edu.ni*

ABSTRACT

In dairy production systems, efficient pasture management is crucial for maximizing milk output while minimizing costs. However, many producers make decisions without considering the productive efficiency of different forage types. This research aims to address this gap by comparing the milk production and related expenses of Brown Swiss and Jersey cows fed with three types of grass: Maralfalfa (*Pennisetum* sp.), Cameroon (*Pennisetum purpureum*), and Mulato (CIAT 36087).The milk production and related expenses for generating one liter of milk from Brown Swiss and Jersey cows were compared when fed with Maralfalfa (*Pennisetum* sp.), Cameroon (*Pennisetum purpureum*), and Mulato (CIAT 36087) grasses. Productive and reproductive parameters affecting milk production were analyzed. Milk production of the cows under study was measured for one month when they were exclusively pasture–fed with Mulato grass. The group of 33 cows was randomly subdivided into three subgroups, each consisting of 11 cows, and each subgroup was assigned to consume a specific type of grass. This resulted in the Maralfalfa consumption group (SG1), the Cameroun consumption group (SG2), and the control group with Mulato pasture feeding (SG3). Daily milk production was recorded for six weeks, with standardized management and *ad libitum* feeding. Daily milk production for each cow was monitored and recorded over the six–week period. Highly significant differences ($P<0.01$) were observed among the three studied groups from the second week onward. The main difference was observed between SG1 and SG3. The highest productivity, with greater milk production volumes, was observed in cows consuming Maralfalfa. However, variables such as the service period, live weight, and number of calving performed better with Cameroon grass. Cost–benefit analysis favored the use of Mulato grass.

Key words: Efficiency; pastures; production; cost; benefit

RESUMEN

En los sistemas de producción lechera, la gestión eficiente de los pastos es crucial para maximizar la producción de leche mientras se minimizan los costos. Sin embargo, muchos productores toman decisiones sin considerar la eficiencia productiva de los diferentes tipos de forraje. Se comparó la producción de leche y los gastos relacionados para generar un litro de leche de vacas Pardo Suizo y Jersey cuando se alimentaron con pastos Maralfalfa (*Pennisetum* sp.) y Cameroon (*Pennisetum purpureum*) y Mulato (CIAT 36087). Se analizaron parámetros productivos y reproductivos que afectan la producción de leche. Se midió la producción de leche de las vacas del estudio durante un mes cuando fueron alimentadas exclusivamente con pasto Mulato. El grupo de 33 vacas se subdividió aleatoriamente en tres subgrupos, cada uno de ellos formado por 11 vacas, y a cada subgrupo se le asignó un consumo de un tipo específico de pasto. Esto resultó en el grupo de consumo de Maralfalfa (SG1), el grupo de consumo de Cameroon (SG2) y el grupo de control alimentado con pasto Mulato (SG3). Se registró la producción diaria de leche durante seis semanas, con manejo estandarizado y alimentación *ad libitum*. La producción diaria de leche de cada vaca fue monitoreada y registrada durante el período de seis semanas. Se observaron diferencias altamente significativas ($P<0,01$) entre los tres grupos estudiados a partir de la segunda semana. La principal diferencia se observó entre SG1 y SG3. La mayor productividad, con mayores volúmenes de producción de leche, se observó en las vacas que consumieron Maralfalfa. Sin embargo, variables como el período de servicio, el peso vivo y el número de nacimientos tuvieron un mejor desempeño con el pasto Cameroon. El análisis costo–beneficio favoreció el uso de pasto Mulato.

Palabras clave: Eficiencia; pastos; producción; costo; beneficio

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INTRODUCTION

Nicaragua consistently faces challenges concerning the feeding of its bovine cattle, especially in the dry corridor regions, as part of its ongoing efforts to maintain or increase milk production levels, all in the backdrop of climate change [1, 2, 3].

In this Nicaraguan context, there has been a notable increase in the adoption of specialized cut–and–carry feeding systems for bovine cattle. This is done to ensure high–quality year–round feeding for the animals, consequently maximizing land utilization, increasing stocking rates per hectare, and ultimately achieving higher volumes of milk and meat production per unit of land area [4, 5].

However, the utilization of improved forages is not a simple practice for small and medium–sized producers, as it tends to elevate their operational costs. According to Martin *et al*. [6], intensive systems that involve irrigation and fertilization in improved pastures can be a viable option for high–genetic–potential dairy cows, provided that the investment is justified. In general, small and medium–sized producers in Nicaragua often do not possess high–genetic–potential dairy cattle (*Bos taurus*) [7, 8]. The establishment and maintenance of improved pastures come with a high cost, and when combined with poor management due to a lack of technical knowledge among producers, it often leads to the waste of forage resources [9] The pastures most commonly employed in these feeding systems include Cameroon (*Pennisetum purpureum*), Maralfalfa (*Pennisetum purpureum*), King Grass (*Pennisetum purpureum*), Napier (*Pennisetum purpureum*), Pasto Cuba 22 (*Pennisetum purpureum*), CT-115 (*Pennisetum purpureum*), Maize (*Zea mays*), among others [10] . Few studies have compared the milk production capacity of these cut–and–carry forages and the breeds considered in this study.

The primary aim of this research was to determine the efficiency in production and analyze the relationship between costs and benefits in milk production through the utilization of pastures such as Maralfalfa (*Pennisetum* sp.), Cameroon (*Pennisetum purpureum*), and Mulato II (CIAT 36087). By doing so, it provides farmers with a tool to make informed decisions regarding the type of pasture to use in their dairy production.

The significance of this study lies in providing farmers and livestock breeders with guidance to choose the most cost–effective pasture options available in the region, based on productive efficiency and cost–benefit outcomes [11, 12] the findings of this research can have a substantial economic impact by offering insights into which pasture is the most profitable in terms of production costs and milk yield.

This research goes beyond merely comparing milk production among cattle breeds; it also takes into account three different types of pastures. This broadens the scope of the study, allowing for the evaluation of multiple variables and their interactions.

In summary, this research fills a crucial gap by addressing the interaction between multiple variables (cattle breed and pasture types), considering cost and profitability perspectives, and recognizing livestock diversity and the significance of management in milk production. These elements make the study unique and highly relevant in the field of dairy production and livestock feeding [12, 13].

MATERIALS AND METHODS

Randomly selected from a population of 240 milking cows, 33 cows of Brown Swiss and Jersey breeds were chosen for this study. These cows were part of the Santa Teresa farm located in Villanueva Chinandega, Nicaragua (12°45'21.4" N | 87°01'07.1" W). In the study area, the environmental conditions are tropical savanna climate, ranging from the Pacific area and the western foothills of the central mountain range. It has average temperatures between 21°C and 30°C and maximum temperatures up to 41°C. It is characterized by a dry season from November to April, the maximum annual rainfall is 2,000 mm and the minimum between 700 and 800 mm annually.

Parameters considered for selecting the cows in this study included lactation status (not more than 60 days (d) open), healthy udders, and the absence of physiopathological issues [14] and the data is disposal in the Mendeley repository [15].

The milk production per cow per day was assessed over 30 consecutive d for the selected cows, with them being exclusively pasture–fed with Mulato II (CIAT 36087) to obtain their initial productions for subsequent comparisons. Milk production was measured using volumetric methods, utilizing BouMatic Xcalibur equipment, manufactured in the United States, which is commonly employed for precise measurement in dairy farming. After the initial monitoring period for individual daily cow production, the group of cows was randomly subdivided into three subgroups, each containing 11 cows, and each subgroup was assigned a specific type of grass to consume.

Consumption Subgroup 1 (SG1), grazing is the primary method. Regrowth days are managed carefully to optimize yield and quality, with a rotation plan ensuring adequate recovery periods between grazing sessions. The stocking rate is adjusted based on forage availability and growth rates. In Consumption Subgroup 2 (SG2), which includes Cameroon (*Pennisetum purpureum*), the forage is cut and fed in stalls every 60 d. This method allows for controlled regrowth, ensuring the forage reaches optimal quality before harvesting. Specific plot numbers are utilized for rotation to minimize overgrazing and promote healthy regrowth. For Consumption Subgroup 3 (SG3), which features Mulato II, continuous grazing is employed, maintaining the forage at an optimal size. This practice allows for consistent availability while supporting regrowth. Stocking rates are monitored closely to prevent overgrazing, ensuring the pasture remains healthy and productive. From a genetic (breed) standpoint, the three groups were heterogeneous, consisting of Brown Swiss and Jersey cows in very similar proportions, and thus, no a prior advantage was assumed for any group. Environmental factors (temperature, housing, humidity, etc.) were the same for all three groups, except for the feed, which was our independent variable, and from which we expected to generate productivity differences.

The individual milk production per cow per day was measured for a period of 42 d using calibrated liters. The measurements were conducted using BouMatic Xcalibur equipment (USA), ensuring accurate and consistent data collection. Environmental and housing conditions for the cows were standardized across all three subgroups. Feeding was *ad libitum* and represented the independent variable since the type of grass consumed was different for each subgroup.

The study analyzed and compared the biological conversion efficiency, as well as the economic aspects of the production system to quantify the impact of the independent variable within the system.

For data analysis, the basic package of descriptive statistics in Excel was used to calculate mean, standard deviations, and coefficients of variation. To estimate differences between subgroups, ANOVA [16] and the Tukey test were used to identify significant differences [17].

The productive and reproductive parameters analyzed in this study included daily milk production per cow, live weight, age at first calving, open days, and the number of calvings, with their values derived from individual records [18, 19] .

$$P = Tm \times Mc \times Pd \qquad (1)$$

Where:

P = Production cow.milk^{-1}.day^{-1}
Tm = total production of milk
Mc = # milking cow
Pd = # production days

The productive variable, Milk production·ha^{-1}·year^{-1}, was calculated using the formula (2):

$$PR = PLT \times VO \times ha \qquad (2)$$

Where:

PR= Production (L.cow^{-1}.ha^{-1}.year^{-1}).
PLT: Total Production of milk (L).
VO: # Cows in milking.
ha: # hectares dedicated to livestock per year

The methodology employed for comparing the productive capacity of the studied types of grass was based on the differences in percentages and average calculations within the three analyzed subgroups to determine which of the grasses yielded the best results.

The net benefit was calculated using the formula (3) proposed by Wadsworth [20] and applied to livestock:

$$BN = IT - CT \qquad (3)$$

Where:

BN: Benefit–Cost Net
IT: Total Income (USD$)
CT: Total Costs (USD$)

The cost–benefit relationship was calculated using formula (4) proposed by Vargas and Cuevas [14]:

$$RBC = IT \,.\, CT^{-1} \qquad (4)$$

Where:

RBC= B/C: Benefit–Cost Ratio
IT: Total Income (USD$).
CT: Total Costs (US$?).

The cost of one liter of milk was determined using the method proposed by [21] Holman (1993), in which the total costs incurred for the sale of milk are calculated, then divided by the total liters of milk produced (formula 5) :

$$CL = CT \,.\, PTL^{-1} \qquad (5)$$

Where:

CL: Cost per liter of milk (USD$).
CT: Total Cost (USD$).
PTL: Total milk production (L).

RESULTS AND DISCUSSION

The means and standard deviations of the productive and reproductive parameters of group SG1 are presented in TABLE I. The means for open days (OD), live weight, differences in weekly milk production, and number of calving were 47.09 days, 409.18 kg, 43.19 liters, and 2.8 births, respectively.

TABLE I
Basic statistical characteristics of biological variables for group 1 (G1): OD, weight, production difference, age, and calvings

		O.D.	Weight	Production difference	Age	Calvings
N	Valid	11	11	11	11	11
	Lost	0	0	0	0	0
Mean		47.091	409.182	43.1909	6.182	2.818
Medium		47.000	419.000	41.8000	6.000	3.000
Tip. Dev.		8.3241	30.6360	7.84251	1.7215	1.1677
Range		24.0	95.0	29.50	6.0	4.0
Minimum		37.0	355.0	29.60	3.0	1.0
Maximum		61.0	450.0	59.10	9.0	5.0
Percentiles	25	39.000	387.000	37.6000	5.000	2.000
	50	47.000	419.000	41.8000	6.000	3.000
	75	56.000	435.000	49.7000	8.000	4.000

Source: Livestock farm records, processed by ANOVA system.

The fundamental statistical parameters of the biological variables of group SG2 are presented in TABLE II. The means for open days, live weight, number of births, and the differences in weekly milk production were 41.27 d, 339.9 kg, 2.63 births, and 36.32 liters, respectively. These results are similar to the study by Cruz–Hernández *et al.* [22], which also found that different management practices influence milk production. The higher levels of milk production observed in groups fed with Maralfalfa (*Pennisetum* sp) and Cameroon (*Pennisetum purpureum*) under stall–feeding conditions suggest that dietary choices significantly impact productivity [23, 24 and 25].

In TABLE III, the statistics of the biological variables of SG3 are shown. The means for open days, live weight, number of births, and the differences in weekly milk production were 46.81 d, 386.90 kg, 3 births, and 24.98 liters, respectively. These parameters are similar to the study by Cordero [26], and Esquivel–Mimenza *et al.* [27], which highlight that various feeding strategies and management conditions can influence these biological variables. Our study also reveals that feeding with Maralfalfa (*Pennisetum* sp.) and Cameroon (*Pennisetum purpureum*), particularly under stall–feeding conditions, tends to support higher milk production levels. This suggests that while SG3's parameters are comparable to those in other studies, different feeding strategies might still impact production outcomes.

TABLE II
Basic statistical characteristics of biological variables for group 2 (G2): OD, weight, production difference, age, and calvings

		O.D.	Weight	Production difference	Age	Calvings
N	Valid	11	11	11	11	11
	lost	0	0	0	0	0
Mean		41.273	339.909	36.3282	5.455	2.636
Medium		41.000	324.000	35.4000	6.000	3.000
Tip. Dev .		4.6063	43.0127	7.33130	1.5076	1.0269
Range		13.0	113.0	24.79	5.0	3.0
Minimum		36.0	300.0	25.21	3.0	1.0
Maximum		49.0	413.0	50.00	8.0	4.0
Percentiles	25	37.000	310.000	30.2000	5.000	2.000
	50	41.000	324.000	35.4000	6.000	3.000
	75	45.000	400.000	41.3000	6.000	3.000

Source: Livestock farm records, processed by ANOVA system

TABLE III
Basic statistical characteristics of biological variables for group 3 (G3): OD, weight, production difference, age, and calvings

		O.D.	Weight	Production difference	Age	Calvings
N	Valid	11	11	11	11	11
	lost	0	0	0	0	0
Mean		46.818	386.909	24.9873	5.727	3.000
Medium		47.000	398.000	24.1000	6.000	3.000
Tip. Dev .		5.0758	33.9719	6.90207	1.5551	1.2649
Range		18.0	103.0	21.80	5.0	4.0
Minimum		37.0	327.0	15.50	3.0	1.0
Maximum		55.0	430.0	37.30	8.0	5.0
Percentiles	25	43.000	359.000	19.8800	5.000	2.000
	50	47.000	398.000	24.1000	6.000	3.000
	75	51.000	417.000	32.7000	7.000	4.000

Source: Livestock farm records, processed by ANOVA system

The most important biological factors influencing the productive differences in female cattle (as evident in the average productivity of the three groups in this study) are genetics (breed), the environment (facilities, temperature, humidity, altitude, and primarily nutrition in our case), and the number of births. These findings support that nutrition, specifically the type of forage, plays a crucial role in milk production. For instance, feeding with Maralfalfa and Cameroun has been shown to enhance milk production, which aligns with the results of this study. These results are consistent with findings from Villanueva *et al*. [28], WingChing [29], and St–Pierre [30].

All the studys reproductive females were at the peak of their lactation curve, as this was a prerequisite for their selection in the study, and, as a result, it did not affect the average productivity. The mean number of births per group indicates that SG3 had the most lactations, being in its third lactation cycle, which could translate to an advantage in terms of production compared to the other groups (25, 31) (TABLE IV).

TABLE IV displays the mean, standard deviation, and a 95% confidence interval for the three groups. Upon analyzing the upper and lower limits, it is evident that there is no overlap between the values of the groups in any of the weeks, suggesting significant differences among the groups under study.

TABLE V presents the results of comparing the means of milk production in each of the weeks of the experiment for the three subgroups under study. The following results were obtained: In weeks 0 and 1, there was no significant difference (P=0.700) and (P=0.078), respectively, confirming the null hypothesis.

Starting from the 2nd week and onwards (weeks 3, 4, 5, and 6), the differences in productive means among the subgroups of breeders became significant (P<0.001). This leads us to affirm that it is from the second week onwards that the nutritional differences of each of the pastures in the milk production of the breeders are fully established, especially regarding Maralfalfa grass, this would be consistent with the findings of Calzada–Marín *et al.* [10]. When comparing the means between subgroups throughout the experimental period, highly significant differences were found (P<0.001), consistent with Martin *et al.* [6] regarding the productive response of dairy cattle fed improved pastures with proper agroecological management. Similarly, it is expressed and presented by Milera *et al*. [32].

TABLE VI, shows the results of applying the Tukey *post hoc* tests for the subgroups analyzed. These results indicate that the difference in milk production is observed between subgroup SG3 and subgroups SG1 and SG2. This is consistent with Calzada–Marín *et al.* [10].

FIG. 1 illustrates the evolution of milk production for the experimental subgroups. It is evident that all three subgroups started with similar levels of milk production from week 0 to week 1. However, the change in the feeding regimen for subgroups SG1 and SG2 became apparent in their milk production from week 2 onward. SG1 experienced the most significant increase in production, followed by SG2, and finally SG3. Arias and Camargo [33] reported that females fed with Maralfalfa grass (*Pennisetum* sp.) recorded higher levels of milk production, which aligns with our findings. Additionally, considering cost–benefit is fundamental for making financial decisions. This study also found that Mulato II grass was the most cost–effective option, generating higher profits compared to Cameroon (*Pennisetum purpureum*) and Maralfalfa (*Pennisetum* sp.) [34, 35].

Similarly, Milera *et al*. [32] demonstrated that cultivars in intensive systems with irrigation and fertilization of improved grasses are a viable option for dairy cows with high genetic potential, which justifies the investment, while also considering the environmental impacts.

TABLE IV
Basic statistical characteristics of milk production variables by groups

Descriptive		N	Mean	Typical Deviation	Typical error	Confidence interval for the mean at 95%		Minimum	Maximum
						Lower limit	Upper limit		
MP	SG1	11	63.8000	3.57099	1.07670	61.4010	66.1990	55.00	69.30
	SG2	11	64.8900	3.76897	1.13639	62.3580	67.4220	57.40	70.00
	SG3	11	63.1218	6.77389	2.04240	58.5711	67.6726	55.30	74.20
	Total	33	63.9373	4.82809	0.84046	62.2253	65.6492	55.00	74.20
Week 1	SG1	11	67.2000	4.34948	1.31142	64.2780	70.1220	57.20	73.70
	SG2	11	66.8318	3.71081	1.11885	64.3389	69.3248	58.60	71.20
	SG3	11	63.1636	5.12919	1.54651	59.7178	66.6095	56.20	72.30
	Total	33	65.7318	4.67553	0.81391	64.0739	67.3897	56.20	73.70
Week 2	SG1	11	76.100	4.6844	1.4124	72.953	79.247	64.4	80.6
	SG2	11	73.245	4.2276	1.2747	70.405	76.086	67.1	80.5
	SG3	11	64.000	4.6951	1.4156	60.846	67.154	56.7	71.0
	Total	33	71.115	6.8437	1.1913	68.688	73.542	56.7	80.6
Week 3	SG1	11	87.809	4.3418	1.3091	84.892	90.726	78.8	94.2
	SG2	11	81.436	4.8876	1.4737	78.153	84.720	72.3	89.1
	SG3	11	72.155	4.3115	1.3000	69.258	75.051	65.9	79.8
	Total	33	80.467	7.8594	1.3681	77.680	83.253	65.9	94.2
Week 4	SG1	11	95.527	7.0166	2.1156	90.813	100.241	84.0	106.0
	SG2	11	89.918	5.4393	1.6400	86.264	93.572	80.8	100.1
	SG3	11	81.964	5.0208	1.5138	78.591	85.337	73.7	90.3
	Total	33	89.136	8.0277	1.3974	86.290	91.983	73.7	106.0
Week 5	SG1	11	101.555	8.4248	2.5402	95.895	107.214	86.8	112.4
	SG2	11	96.109	5.8391	1.7606	92.186	100.032	88.4	106.3
	SG3	11	86.418	5.5427	1.6712	82.695	90.142	76.0	92.7
	Total	33	94.694	9.1020	1.5845	91.467	97.921	76.0	112.4
Week 6	SG1	11	106,991	8.6123	2.5967	101,205	112,777	92.2	122.1
	SG2	11	101,218	5.9476	1.7933	97,223	105,214	91.0	111.0
	SG3	11	88,109	5.7861	1.7446	84,222	91,996	77.0	94.5
	Total	33	98,773	10.4430	1.8179	95,070	102,476	77.0	122.1
Difference	SG1	11	43.1909	7.84251	2.36460	37.9222	48.4596	29.60	59.10
	SG2	11	36.3282	7.33130	2.21047	31.4029	41.2534	25.21	50.00
	SG3	11	24.9873	6.90207	2.08105	20.3504	29.6241	15.50	37.30
	Total	33	34.8355	10.44065	1.81748	31.1334	38.5375	15.50	59.10

SG1: Cows fed with Maralfalfa grass. SG2: Cows fed with Cameroun grass. SG3: Cows fed with Mulato II grass. MP: stands for milk production, measured in liters per week

In week 0, the average production of all three study groups ranged from 60 to 70 liters. However, as the study concluded in the last week (week 6), the production averages varied. SG1 showed approximately 100 to 110 liters, SG2 ranged between 90 and 110 liters, and SG3's production was in the range of 80 to 90 liters. These results indicate that SG1 had the most substantial growth in milk production over the course of the 6-week study. These results differ from those presented by Campos Granados [36], who states that the nutritional differences between these varieties in terms of composition do exist, but are not as pronounced as once thought.

The results of the random comparison of the distribution of Jersey cows in the subgroups are shown in TABLE VII. The distribution was 4, 7, and 4 for SG1, SG2, and SG3, respectively. The average milk production for these groups was 98 L for SG2, 101.4 L for SG1, and 92.4 L for SG3. The highest standard deviation was 9.4 for SG1, and the lowest was 2.87 for SG3.

TABLE VIII displays the results for the random distribution of Brown Swiss cows, with the highest number of Brown Swiss cows placed in SG3 and SG1, each with 7, and 4 in SG2. The average milk production for these groups was 106.8, 110.1, and 85.6 L for SG2, SG1, and SG3, respectively. The standard deviation was 3.17 for SG2, the lowest degree of dispersion, and 6.77 for SG1, the highest.

TABLE V
Comparison of the productive means of the subgroups

		Sum of squares	DF	Quadratic meaning	F	Sig. or *P*
MP	Inter–groups	17.506	2	8.753	0.360	0.700
	Intra – groups	728.427	30	24.281		
	Total	745.933	32			
Week 1	Inter–groups	109.572	2	54.786	2.786	0.078
	Intra – groups	589.967	30	19.666		
	Total	699.539	32			
Week 2	Inter–groups	880.135	2	440.068	21.342	0.000
	Intra – groups	618.607	30	20.620		
	Total	1.498.742	32			
Week 3	Inter–groups	1.363.372	2	681.686	33.346	0.000
	Intra – groups	613.282	30	20.443		
	Total	1.976.653	32			
Week 4	Inter–groups	1.021.933	2	510.966	14.736	0.000
	Intra – groups	1.040.264	30	34.675		
	Total	2.062.196	32			
Week 5	Inter–groups	1.293.146	2	646.573	14.284	0.000
	Intra – groups	1.357.933	30	45.264		
	Total	2.651.079	32			
Week 6	Inter–groups	2.059.551	2	1029.775	21.600	0.000
	Intra – groups	1.430.235	30	47.674		
	Total	3.489.785	32			
Differences	Inter–groups	1.859.314	2	929.657	17.122	0.000
	Intra – groups	1.628.913	30	54.297		
	Total	3.488.227	32			

Note: MP=Milk production

TABLE VI
Tukey's *post hoc* test

Group 1	N	Subset for alpha = 0.05	
		1	2
SG3	11	24.9873	
SG2	11		36.3282
SG1	11		43.1909

Tukey B [a] to. Use the sample size of the harmonic mean = 11,00

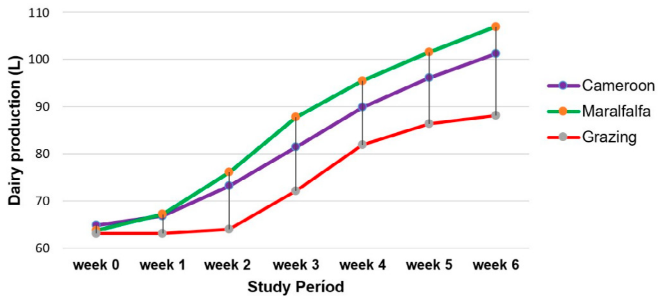

FIGURE 1: Evolution of milk production of the experimental subgroups: Cameroon (SG2), Marafalfa (SG1) and Grazing or Mulato (SG3)

TABLE VII
Descriptive one–way ANOVA for the random distribution of the Jersey breed

	N	Mean	Typical Deviation	Typical Error	Confidence interval for the mean at 95%		Min.	Max.
					Lower limit	Upper limit		
SG2	7	98.000	4.5494	1.7195	93.793	102.207	91.0	105.3
SG1	4	101.400	9.4865	4.7432	86.305	116.495	92.2	112.0
SG3	4	92.400	2.8787	1.4393	87.819	96.981	88.4	94.5
Total	15	97.413	6.4672	1.6698	93.832	100.995	88.4	112.0

TABLE VIII
Descriptive one–way ANOVA for the random distribution of the Brown Swiss breed

	N	Mean	Typical Deviation	Typical Error	Confidence interval for the mean at 95%		Min.	Max.
					Lower limit	Upper limit		
SG2	4	106.850	3.1723	1.5861	101.802	111.898	103.6	111.0
SG1	7	110.186	6.7731	2.5600	103.922	116.450	102.0	122.1
SG3	7	85.657	5.6891	2.1503	80.396	90.919	77.0	92.0
Total	18	99.906	12.9556	3.0537	93.463	106.348	77.0	122.1

TABLE IX
***Post hoc* multiple comparison of milk production in Jersey cows**

(j) group	(p) group	Mean difference (jp)	Typical Error	Next.	Confidence interval for the mean at 95%	
					Lower limit	Upper limit
SG2	SG1	-6.720	3.75156	0.214	-16.7287	3.2887
	SG3	0.205	3.75156	0.998	-9.8037	10.2137
SG1	SG2	6.720	3.75156	0.214	-3.2887	16.7287
	SG3	6.925	4.23233	0.269	-4.3663	18.2163
SG3	SG2	-0.205	3.75156	0.998	-10.2137	9.8037
	SG1	-6.925	4.23233	0.269	-18.2163	4.3663

j = Jersey p = Brown Swiss

When conducting multiple comparisons of milk production among Jersey cows fed different types of forage, no significant differences were found, indicating that there is no advantage of having 7 Jersey cows in SG1 and SG2 over the 4 Jersey cows in SG2. See TABLE IX.

When conducting multiple comparisons of milk production among Brown Swiss cows in the different groups, a significant difference ($P<0.05$) was found between SG3 and the SG1 and SG2 groups, respectively. This indicates a positive productive response capacity of the Brown Swiss breed to changes in forage with different nutritional levels, in our case, in favor of Maralfalfa (TABLE X).

TABLE X *Post hoc* multiple comparison of the production of Swiss Brown cows						
(j) group	**(p) group**	**Mean difference (jp)**	**Typical Error**	**Next.**	**Confidence interval for the mean at 95%**	
					Lower limit	**Upper limit**
SG2	SG1	-2.58571	3.60162	0.757	-11.9408	6.7694
	SG3	22.06286*	3.60162	0.000	12.7078	31.4180
SG1	SG2	2.58571	3.60162	0.757	-6.7694	11.9408
	SG3	24.64857*	3.07147	0.000	16.6705	32.6266
SG3	SG2	-22.06286*	3.60162	0.000	-31.4180	-12.7078
	SG1	-24.64857*	3.07147	0.000	-32.6266	-16.6705

j = Jersey, p = Brown Swiss

Furthermore, it can be observed that the thermoregulation capacity and milk production of the Brown Swiss breed are affected under high–temperature conditions during grazing. The Brown Swiss breed exhibited higher levels of milk production in the groups fed with Maralfalfa and Cameroun under stall–feeding conditions. This finding is significant and supports the importance of feeding and management conditions in the milk production of the Brown Swiss breed [23, 24]. The fact that higher levels of milk production were recorded in the groups fed with Maralfalfa (*Pennisetum* sp.) and Cameroon (*Pennisetum purpureum*), especially under stall–feeding conditions, suggests that these grasses and environments provide favorable support for the lactation of this breed.

This may have practical implications for the livestock industry as it indicates that the choice of diet and care environment can have a positive impact on the productivity of Brown Swiss breeders [37]. Furthermore, it could be considered as an important factor in decision–making in dairy livestock management to optimize production and profitability. This result may also be relevant to other researchers and breeders involved in breeding cattle of this breed, as it suggests the importance of selecting appropriate feed and management practices to maximize milk yield in Brown Swiss [38, 39].

In FIG. 2, milk productions of the breeds within the groups are illustrated, and significant differences ($P<0.01$) are found between SG3 and SG1, as well as between SG3 and SG2 regarding the Brown Swiss breed. The productive response of both breeds was superior when consuming Maralfalfa grass, resulting in higher milk production compared to their lower production when consuming Mulato II.

TABLE XI, presents descriptive data regarding the number of calvings per cow in the 3 study groups, consisting of a total of 33 cows. It is observed that the most frequent value is 3 calvings, with a total of 12 cows achieving this number. The highest productive average is found in 5 cows that have had 4 calvings, with an average production of 38.2 liters. These results reflect a physiological pattern established by the lactation curve, theoretically indicating that the peak of milk production is reached in the third or fourth calving of the cows.

In TABLE XII see the results of the one–way ANOVA applied to the number of calvings of cows in the different groups and their milk production are shown, and no significant influence was found (P=0.892).

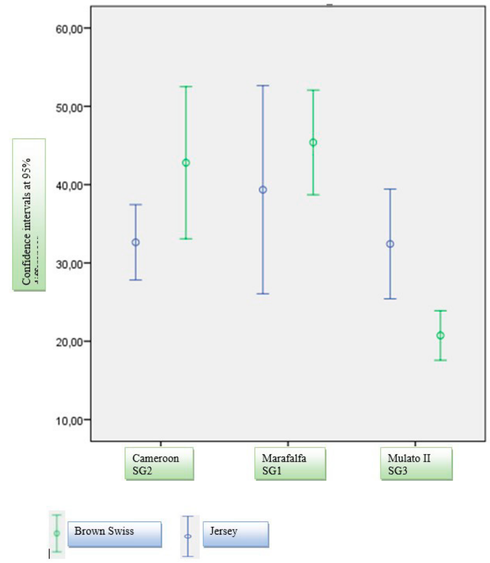

FIGURE 2. Milk production of breeds by groups

TABLE XI Descriptive influence of calving on milk production								
p	**N**	**mean**	**Typical Deviation**	**Typical Error**	**Confidence interval for the mean at 95%**		**Min.**	**Max.**
					Lower limit	**Upper limit**		
1	4	33.2000	13.38158	6.69079	11.9069	54.4931	17.80	50.00
2	9	33.9322	11.51742	3.83914	25.0792	42.7853	15.50	49.70
3	12	35.6483	10.38692	2.99844	29.0488	42.2479	20.18	59.10
4	5	38.2200	9.85175	4.40584	25.9874	50.4526	22.70	50.00
5	3	30.8333	9.57932	5.53062	7.0370	54.6297	24.10	41.80
Total	33	34.8355	10.44065	1.81748	31.1334	38.5375	15.50	59.10

TABLE XII One–factor ANOVA of parity number					
Difference	**Sum of squares**	**DF**	**Quadratic meaning**	**F**	**Sig. or *P***
Inter–groups	131.297	4	32.824	0.274	0.892
Intra – groups	3356.930	28	119.890		
Total	3488.227	32			

TABLE XIII illustrates the distribution and quantity of cows based on the number of calvings (1, 2, 3, 4, and 5) in the different groups. It is observed that cows with 3 calvings are the most numerous, totaling 12 cows, with 5 in SG2, 3 in SG1, and 4 in SG3. This random distribution could potentially represent a productive advantage for SG2 in relation to SG1. Cows with 4 calvings numbered 5 in total, with 2 in SG2, 2 in SG1, and 1 in SG3. The distribution could represent a productive advantage for SG3 in relation to SG2.

The costs of establishing 1 ha of improved forage in the study are presented in TABLE XIV. The establishment cost for 1 ha of

TABLE XIII
Contingency table of calving in the study groups

Count		Group 1			Total
		G2	G1	G3	
Calving cow 1	1	2	1	1	4
	2	2	4	3	9
	3	5	3	4	12
	4	2	2	1	5
	5	0	1	2	3
Total		11	11	11	33

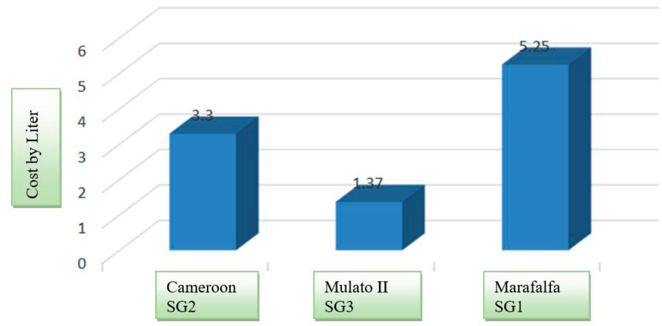

FIGURE 3. Production cost of 1 liter of milk in the different groups under study

Maralfalfa grass is $1,707.96, for Mulato II grass is $2,930.27, and for Cameroun grass is $1,635.06.

The green matter production per ha for Cameroun grass was 38,020 kg·ha^{-1} with an average cost per ton of $43.00, for Mulato II grass (CIAT 36087) it was 35,808 kg·ha^{-1} with an average cost per tonne of $81.85, and for Maralfalfa grass (*Pennisetum* sp.), it was 33,100 kg·ha^{-1} of green matter with an average cost per tonne of $199.43.

Table XIV
The cost of production of one L of milk by groups of breeders in our study

Grass	Cameroon	Mulato II	Maralfalfa
Investment per cycle ($)	1,635.06	2,930.27	1708.96
Fresh Biomass (kg)	38,020	35,808	33,100
Income ($)	2,630.09	2,330.47	2,635.99
Intake (kg)	44.86	38.72	54.00
Cost per kilogram ($)	0.43	0.82	0.52
Ration Cost ($)	1.38	0.49	2.18
Total production (L·group^{-1})	5,596.35	4,957.20	5,602.60
Production Milk / Dairy Liter	12.11	10.72	12.12
Sale price ($)	0.47	0.47	0.47
Cost.per litre ($)	0.11	0.05	0.18

Source: Taken from farm records

The costs of investment per cycle and type of grass are presented in TABLE XIV, with Maralfalfa being clearly the most expensive at $1,708.96, compared to $1,635.06 for Cameroun.

The cost of different pastures for the production of one litre of milk is shown in FIG. 3. It can be produced more affordably at $0.49 per litre with Mulato II grass (CIAT 36087) and more expensively at $0.18 per litre with Maralfalfa grass (*Pennisetum* sp.), followed by Cameroon grass (*Pennisetum purpureum*) with a cost of $0.05 per litre. Productivity and efficiency of specialized dairy farms in the Valle del Cauca (Colombia) by Morales – Vallecilla and Ortiz–Grisales [40] present lower costs, despite being in larger and more technologically advanced operations.

However, we assume that despite the production costs of one litre of milk with Maralfalfa, in intensive production systems and with dairy cows with high genetic potential for milk production, costs can be significantly reduced due to higher production volumes. It is worth noting that Mulato II grass proved to be the most cost–effective option, generating higher profits compared to Cameroon (*Pennisetum purpureum*) and Maralfalfa (*Pennisetum* sp.) [23, 24].

This finding indicates that the production cost per litre of milk is lower in breeders fed with Mulato II (CIAT 36087) [41]. However, it is important to consider that, despite this lower cost, Maralfalfa (*Pennisetum* sp.) demonstrated a superior productive response. This observation suggests that, if milk production volumes with Maralfalfa (*Pennisetum* sp.) can be increased, overall costs could be lowered, thereby increasing profitability.

In practical terms, this discussion highlights the importance of balancing cost efficiency and production to maximize profitability in dairy farming [42]. It is crucial to consider both production performance and the costs associated with feeding to make informed decisions in livestock management and pasture selection. Additionally, these results can have significant implications for producers seeking to optimize their milk production and profitability in the livestock industry [43].

CONCLUSION

According to our results, the group of breeders that consumed Maralfalfa grass (*Pennisetum* sp.) showed the best productive response with higher milk production volumes compared to the groups fed with Mulato II (CIAT 36087) and Cameroon (*Pennisetum purpureum*) from the second week of the experiment.

The values of the variables (Service period, live weight, and number of calving) showed a more uniform and compact pattern in the Cameroon group, with greater variability in the Maralfalfa and Mulato groups. The Brown Swiss breeders exhibited higher levels of milk production in the groups fed with Maralfalfa (*Pennisetum* sp.) and Cameroon (*Pennisetum purpureum*) under stall–feeding conditions. However, a lower productive response was observed in the group fed with Mulato while grazing, suggesting better adaptability of this breed to comfortable feeding and management conditions, in contrast to its lower adaptability to stress from high temperatures.

In terms of cost–benefit, the implementation of Cameroon (*Pennisetum* sp.), Maralfalfa (*Pennisetum* sp.), and Mulato II (CIAT 36087) grasses in milk production proved to be more profitable for Mulato II grass (CIAT 36087), as it generated higher profits.

The cost of producing one litre of milk was lower in the breeders fed with Mulato II grass, followed by Cameroon (*Pennisetum purpureum*) and Maralfalfa (CIAT 36087). However, given the superior productive response of Maralfalfa grass, it is possible to reduce costs with higher milk volumes.

Ethics statement

No experiments were performed on animals or people. The protocol to carry out this research was reviewed and confirmed to proceed by the National Autonomous University of Nicaragua Leon. No formal ethical approval was required for this study according to the Personal Data Protection Act. LAW NO. 787, regarding the ethical approval requirements for this type of study. Verbal consent was used instead of written consent because the aforementioned law does not require written consent to be bound by it.

Conflict of interest

The authors declare that they have no competing interests.

Grant information

No funding for this research was disclosed**.**

Data availability

Underlying data Mendeley: Data for Comparison of milk production of Maralfalfa (*Pennisetum* sp.), Cameroun (*Pennisetum purpureum*) and Mulato (CIAT 36087) in dairy cattle. https://data.mendeley.com/datasets/n7mfwys6sy/1 [15].

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