Article

Not peer-reviewed version

Botanical Composition of the Diet of Grazing Cows During the Dry Season in a Subtropical Region of Mexico

Felisa S. Jiménez-Peralta , Manuel Gonzalez-Ronquillo , Anastacio García-Martínez , Sherezada Esparza-Jiménez , Benito Albarrán-Portillo *

Posted Date: 8 January 2026

doi: 10.20944/preprints202601.0584.v1

Keywords: alternative forages; drought; grazing; silvopastoral; botanical composition of the diet; selection index

 doi:10.20944/preprints202601.0584.v1

Article

Botanical Composition of the Diet of Grazing Cows During the Dry Season in a Subtropical Region of Mexico

Felisa S. Jiménez-Peralta [1], Manuel González-Ronquillo [2], Anastacio García-Martínez [1], Sherezada Esparza Jiménez [1] and Benito Álbarrán Portillo [1,*]

[1] Centro Universitario UAEM Temascaltepec Universidad Autónoma del Estado de México, Carretera Toluca - Tejupilco Km. 67.5 Temascaltepec de González, Estado de Mexico, Mexico 51300

[2] Facultad de Medicina Veterinaria y Zootecnia Universidad Autónoma del Estado de México. El Cerrillo, Piedras Blancas, Toluca, Estado de Mexico, Mexico 50295

* Correspondence: balbarranp@uaemex.mx; Tel.: +52-722-405-6375

Simple Summary

Tropical and subtropical cattle production systems used local resources to produce milk and beef under extensive grazing with limited supplementation during the dry season. Lactating cows graze in complex agroecosystems compiled of native and introduced grasses in pastures with scattered shrubs and trees that are part of the cow's diets with varied nutritional composition. Results provide information about the cows botanical composition of the diet and the nutrients obtained from forages like *Cynodon plectostachyus* and the woody specie *Vachellia farnesiana*, *Pithecellobium dulce*, *Guazuma ulmifolia*, and *Ficus sp*. The knowledge of the alternative fodder resources consumed by the cows and their nutritional contributions, can be used to develop efficient and sustainable management practices.

Abstract

Introduction of livestock into tropical and subtropical forest areas has displaced the original forest vegetation. Posterior surge of secondary vegetation has served as a source of alternative forage to cattle during scarcity periods. The objective of the study was to determine the botanical composition of the diet (BCD) and the productive performance of lactating Brown Swiss cows during the dry season. The BCD was determined through microhistological analysis of fecal samples of grazing cows. Grazing areas were sampled to determine morphological and botanical composition (BCP). Forages were sampled to determine their chemical composition. Cow's productive variables were recorded during March, April, and May of 2012. The BCP and BCD consisted of *Cynodon plectostachyus* and the woody species were *Vachellia farnesiana*, with smaller proportions of *Pithecellobium dulce*, *Guazuma ulmifolia*, and *Ficus sp*. These forages contributed with 63, 48, and 47% of the dry matter, metabolizable energy, and metabolizable protein requirements of the cows. Therefore, it is concluded that alternative forages contributed significantly to the nutritional requirements during periods of pasture scarcity. Understanding the botanical composition of the diet of grazing cows allows for the development of management strategies based on the efficient use of local resources.

Keywords: alternative forages; drought; grazing; silvopastoral; botanical composition of the diet; selection index

 doi:10.20944/preprints202601.0584.v1

1. Introduction

In various regions of the world there is an animal production based on extensive grazing and agrosilvo pastoral systems [1], which low inputs allow animal production based on native forage resources, that contribute to the nutritional requirements of cattle during the dry season and forage scarcity [2].

In tropical and subtropical regions of the Americas, the introduction of cattle has transformed forests by displacing native plant species with grasses species established in monoculture pastures. Following the initial displacement of native species, secondary vegetation appears, which has been used by cattle during periods when forage is scarce in pastures or its nutritional quality decreases, representing a great diversity of alternative forage with divers nutritional composition [3].

The above has generated the need to study this type of system called silvopastoral, or agrosilvopastoral, which are complex, with a great diversity of plant species and diverse and variable chemical composition depending on the time of year [4].

The southwestern region of the State of Mexico is a mountainous region with poor soils and steep slopes unsuitable for agriculture. Therefore, livestock farming is the best way to use land resources. Production units are called dual-purpose because they produce both milk and beef. During the rainy season, the cattle feed exclusively on forages available in grazing areas, while during the dry season due to the decrease in the quantity and quality of available forage, producers must supplement their cattle, which has a significant economic impact on production costs [5]. Producers know that livestock consumes forage from trees and shrubs without knowing the nutritional characteristics of these alternative resources, so management strategies for better use of these resources cannot be developed [6,2].

The objective of this study was to determine the composition of the diet of lactating Brown Swiss cows in a dual-purpose production unit in the southwest of the State of Mexico, during the dry season (March, April and May).

2. Materials and Methods

2.1. Study Area

The study was conducted in a dual-purpose production unit in the municipality of Zacazonapan, State of Mexico, between 19° 00′ 17″ and 19° 16′ 17″ north latitude and between 100° 12′ 55″ and 100° 18′ 13″ west longitude, at an altitude of 1,470 meters above sea level. The climate is classified as semi-tropical, group A, according to the Köppen climate classification, with summer rains and a dry season from November to May, classified as A (c)(w2), with an average annual temperature of 23 °C and an annual rainfall of 1,115 mm [7]. The study was conducted during the months of March, April, and May of 2012, corresponding to the dry season. Each month was considered an experimental period (EP).

2.2. Production and Management of Experimental Cows

The dual-purpose production (PU) unit had an extension of 100 hectares of land with perimeter-fenced, without paddock subdivision, under extensive grazing management. Sixty percent of the PU land was dedicated to forage production compiled of native and introduced grasses, with scattered trees and shrubs, and 40% was destined to crop maize (*Zea mays*), which was subsequently used to prepare cow's supplements.

Overall management of the farm was minimal; there was no fertilization or irrigation of the grazing areas, no conservation practices for surplus forage produced during the rainy season, and minimal inputs restricted to grains for cattle supplements during the dry season.

The PU herd consisted of 25 lactating Brown Swiss cows and their calves. There were also dry cows and a sire, for a total of 60 animals. Milking was performed once a day between 7:00 and 9:00 am. During milking, cows received 4.5 kg of dry matter (DM) per cow per day of supplement and had access to water within the paddocks through a continuously flowing canal. The supplement

 doi:10.20944/preprints202601.0584.v1

consisted of a mixture of cracked corn ear with husk and soybean meal, containing 14% of crude protein. The cows remained in the paddocks 24 hours a day, 365 days a year.

2.3. Experimental Cows and Sampling

From the total number of cows in the herd, five cows were randomly selected to collect fecal samples taken directly from the rectum at the end of milking for two consecutive days in the last week of the EP, in order to determine the BCD, while the remaining lactating cows in the herd were monitored to recorded productive variables and collection of milk samples. The mean body weight (BW) of the cows in the herd was 400 ± 50 kg, with 3.6 ± 1.8 calvings, and 115 ± 33 days of lactation, and a body condition score (BCS) of 2.5 points on a scale of 1 to 5 [8].

Milk yield (MY) was recorded for two consecutive days during the last week of each EP using a 20 kg capacity Rhyno® electronic scale. Cows were weighed after milking on a 1,500 kg capacity Smart Scale 200 (Gallagher®). Body condition score was determined at the same time as cow BW. Milk components, fat, protein end lactose (g/kg), were determined immediately after milking by analyzing a sample with a portable milk analyzer (Lactoscan Milk Analyzer®, Milkotronic). Milk urea nitrogen (MUN) was subsequently determined in the laboratory using enzymatic colorimetry [9].

2.4. Botanical Composition of the Grazing Areas

The herbaceous mass (HM) of the grazing areas GA (mainly grasses) was determined every 28 days using quadrats (n = 6) of 0.25 m² placed within the GA adjacent to where the cows were grazing after milking during the sampling periods, cutting at ground level with shears and, subsequently in the laboratory, were separated by specie to determine the botanical composition of the grazing areas (BCP) according to [10].

2.4.1. Botanical Composition of the Diet

The BCD (percentage of species present) was estimated by identifying epidermal fragments in the feces of the five cows using microhistological analysis. To ensure that the BCD analysis was representative, fecal samples were collected on the same days as the BCP were assessed. The fecal samples were dried in a forced-air oven at 70 °C for 48 h and then ground in a Willey mill with a 1 mm mesh. The BCD was estimated following the procedures described by [11,2].

2.4.2. Woody Species

For two consecutive days during the last week of each EP, and by direct observation during grazing after morning milking, and throughout the day until evening (6:00 pm), experimental cows (n = 5) were monitored within the GA to observe the consumption of forage species at ten-minute intervals per grazing event [13]. Samples of plant species (leaves and stems) were taken by hand directly from the plant. The forage samples (approximately 200 g fresh basis) were packaged fresh and transported to the laboratory for chemical analysis.

The chemical composition of the sampled species (leaves and stems) was analyzed to determine dry matter (DM), crude protein (CP), NDF, ADF, and ADL according to [14] (AOAC 1995), and the in vitro digestibility of dry and organic matter was analyzed according to [15]. The in vitro dry matter digestibility (IVDMD) of the main forage species consumed was estimated based on the results of the microhistological analysis. The Estimated Metabolizable Energy (ME) was derived from IVOMD [16]: eME (MJ/kg DM) = 0.0157 *IVOMD.

2.5. Nutrient Intake Estimates

The dry matter intake (DMI) of cows was estimated indirectly from animal performance, using the nutritional composition of the forage and supplements, BW, BCS, and MY and composition, based on estimates from [17]. From the dietary nutritional composition, the contribution of DMI (kg DM/day), metabolizable protein (MP) (g/day), and ME (MJ/kg) from supplements and forages to the

 doi:10.20944/preprints202601.0584.v1

cows' requirements was estimated. Based on this, the contribution of these nutrients to the cows' needs was determined.

2.6. Statistical Analysis

Data on HM, BCP, and BCD were analyzed using descriptive statistics. Animal productive variables were analyzed using a mixed model with the cow as a random effect and the experimental period as a fixed effect, using the SAS MIXED procedure [18] with the following model:

$$Y_{ij} = \mu + EP_i + C_j + e_{ij}$$

Where: Y_{ij} was the response variable, μ was the least square mean, EP_i was the fixed effect of the experimental period (i = March, April and May), C_j was the random effect of the cow (j = 1… 25), and e_{ij} was the random error term.

3. Results

3.1. Herbage Mass

In Table 1 the available HM can be observed in the GA. Average HM was 1,932.7 (kg of DM/ha), with a 50:50 ratio of green to dead material. Of the available HM, 44% was leaf and 56% was stem. The average height in the grazing areas was 2.9 cm.

Table 1. Herbage mass, live material, dead material, leaf and stem (kg of DM/ha) of grazing areas per experimental period (EP) during the dry season.

Variable	EP1	%	EP2	%	EP3	%	Average	%
Herbage mass	1,434.0		2,848.0		1,516.0		1,932.7	
Green material	682.5	48	1,080.5	38	989.7	65	917.55	50
Dead material	751.47	52	1,767.5	62	526.4	35	1,015.1	50
Leaf	755.6	53	936.1	33	717.4	47	803.0	44
Stem	678.5	47	1,911.9	67	786.6	53	1,125.6	56

EP1 = March, EP2 = April and EP3 = May

3.2. Botanical Composition

Table 2 shows the BCP and the CBD of the cows. The following grasses were identified in the grazing areas *Cynodon plectostachyus*, *Paspalum notatum*, *Paspalum convexum*, *Eleusine indica* and *Urochloa brizantha*. *C. plectostachyus* was the most prevalent grass, both in the pasture (57.5%) and in the cows' diet (60.3%).

Additionally, Huizache (*Vachellia farnesiana*, formerly *Acacia farnesiana*) was found in the grazing areas, representing 36.1% of the pasture and 34.3% of the botanical composition of the cows' diet. Other species of the class Magnoliopsida like *Pithecellobium dulce*, *Guazuma ulmifolia*, and *Ficus sp.*, were found in grazing areas as well as in the BCD which together represented 6.4% of the grazing areas and 5.4% of the cows' BCD.

Table 2. Botanical composition of the grazing areas (BCP) and diet (BCD) of cows in the dry season by experimental period.

	Species	EP1		EP2		EP3	
		BCP	BCD	BCP	BCD	BCP	BCD
Grasses	*Cynodon plectostachyus*	59.5	62.8	57.1	60.4	56.0	57.8
Woody	*Vachellia farnesiana*	34.0	33.0	36.0	33.4	38.2	36.5

 doi:10.20944/preprints202601.0584.v1

Other species *	*Phitecellobium dulce, Guazuma ulmifolia, and Ficus sp.*	6.5	4.2	6.9	6.2	5.8	5.7

EP1 = March; EP2 = April; EP3 = May * In certain cases, it was only possible to identify the epidermal particles at the class level belonging to the Magnoliopsida class

3.3. Chemical Composition of Forages

Table 4 shows the chemical composition of the main species identified in the cows' diet. *C. plectostachyus* had a low nutritional value with 77.2 (g/kg of DM) of CP, low NDF, high levels of ADF and low ADL, resulting in a low digestibility of 657.3 (g/kg of DM) and a low ME content of 7.2 (MJ/kg of DM). In contrast, the woody species had a high CP content, ranging from 228.2 of *V. farnesiana* to 109.5 (g/kg of DM) of *Ficus sp*.

Table 4. Chemical composition (g/kg of DM) of the species present in the diet of grazing cows during the dry season.

Item	Supplement	*Cynodon plectostachyus*	*Vachellia farnesiana*	*Pithecellobium dulce*	*Guazuma ulmifolia*	*Ficus sp*
DM	943.2	714.1	897.5	607.4	456.7	702.4
OM	846.0	927.7	946.2	893.8	883.9	911.3
ASH	NA	68.2	57.8	106.3	113.1	88.7
CP	110.7	77.2	228.2	195.6	168.2	109.5
NDF	349.5	63.7	359.9	362.2	491.0	346.7
ADF	109.6	374.2	224.7	227.4	180.0	203.2
ADL	13.0	42.0	114.1	104.9	79.6	79.8
IVDMD	908.0	657.3	470.7	512.6	651.2	473.0
ME	11.9	7.2	14.1	13.8	13.9	13.7

DM = Dry Matter, OM = Organic Matter, ASH = Ashes, CP = Crude Protein, ADF = Acid Detergent Fiber, NDF = Neutral Detergent Fiber, ADL = Acid Detergent Lignin. Metabolizable Energy, IVDMD = In vitro dry matter digestibility, ME MJ/kg of DM

Neutral detergent fiber content ranged from 346.8 (g/kg of DM) for *Ficus sp*., to 491.0 (g/kg of DM) for *G. ulmifolia* . However, the digestibility of woody species was lower than those of *C. plectostachyus* , with the highest value for *G. ulmifolia* at 651.2 (g/kg of DM) and the lowest for *V. farnesiana* at 470.7 (g/kg of DM). Metabolizable energy of consumed species were generally high, ranging from 13.7 (MJ/kg of DM) of F. sp., to 14.1 (MJ/kg of DM).

3.4. Content of Secondary Compounds

Table 5 shows the total phenolic (TP), saponin (SA), and aqueous fraction (AF) contents of the forage species identified in the cow's BCD. *P. dulce* had the highest TP content, while the values for the remaining species were similar, ranging from 12.7 (g/kg of DM) of *C. plectostachyus* to 19.3 (g/kg of DM) of *Ficus sp*. Regarding SA, the highest values were for *Ficus sp*., with 37.4 (g/kg of DM), followed by *V. farnesiana* with 21.0 (g/kg of DM); the values for the remaining species ranged from 12.3 (g/kg of DM) to 14.1 (g/kg of DM) of *C. plectostachyus* and *G. ulmifolia*, respectively. Finally, the FA values ranged from 149.5 as the highest for *G. ulmifolia*, to 90.3 (g/kg of DM) as the lowest for *C. plectostachyus*.

 doi:10.20944/preprints202601.0584.v1

Table 5. Table of secondary compound content (g/kg of DM) present in the species consumed by cows during the dry season.

Species	Total phenols	Saponins	Aqueous fractions
Cynodon plectostachyus	12.7	13.8	90.3
Vachellia farnesiana	15.3	12.3	111.5
Pithecellobium dulce	51.1	21.0	102.0
Guazuma ulmifolia	14.0	14.1	149.5
Ficus sp.	19.3	37.4	116.9

3.5. Productive Variables

Table 6 shows the productive variables of the cows. There were no significant differences in most of the cows' productive variables ($P > 0.05$), except for milk fat and protein content (g/kg), and BCS ($P < 0.01$). Increases in milk fat content were observed from EP1 (32.0 g/kg) to EP3 (39.1 g/kg); while the opposite occurred in protein content, which decreased from 30.3 (g/kg) in EP1 to 29.7 (g/kg) in EP3. BCS increased significantly ($P = 0.03$) from 2.59 in EP1 to 2.52 in EP3.

The mean DMI was 11.4 (kg/cow/day), while the mean MY was 5.6 (kg/cow/day). The mean values for lactose, MUN, and BW were 42.5 (mg/kg), 14.0 (mg/dL), and 414.5 (kg/cow), respectively.

Table 6. Productive variables per experimental period (EP) of grazing cows during the dry season.

Variable	EP1	EP2	EP3	P =	SEM
DMI (kg/day)	11.5	11.3	11.5	0.45	0.40
Milk (kg/cow/day)	5.9	5.6	5.3	0.15	0.27
Fat (g/kg)	32.0^{a}	35.1^{ab}	39.1^{b}	0.001	1.98
Protein (g/kg)	30.3^{a}	30.4^{a}	29.7^{b}	0.004	0.31
Lactose (g/kg)	41.6	43.3	42.5	0.63	1.1
MUN (mg/dL)	13.8	14.4	13.7	0.92	2.0
BW (kg)	420.6	406.3	416.7	0.16	11.9
BCS	2.49^{ab}	2.42^{a}	2.52^{b}	0.03	0.04

DMI = dry matter intake, MUN = milk urea nitrogen, Body weight = Body weight, BCS = body condition score

3.6. Nutrient Contribution

In Table 7 are shown the contributions of dry matter, ME, and MP of supplement and forage (*C. plectostachyus*, *V. farnesiana*, *P. dulce*, *G. ulmifolia* and *F. sp.*). The supplement provided 37% of the estimated dry matter intake, while forages provided 63%. Regarding ME and MP contributions, the supplements provided 52 and 53%, respectively, while the forages provided 48 and 47%, respectively.

Table 7. Contribution of estimated dry matter intake (DMI), metabolizable energy (ME) (MJ/day) and metabolizable protein (MP) (g/day), of grazing cows in the dry season.

	DMI	ME	MP
Supplement	4.5 (37%)	61.9 (52%)	462.0 (53%)
Forage*	7.0 (63%)	57.6 (48%)	403.3 (47%)
Total	11.5	119.5	865.3

**C. plectostachyus* contributed 60%, *V. farnesiana* 34%, and together *P. dulce*, *G. ulmifolia*, and *Ficus. sp.* contributed 6% of the forage dry matter intake

 doi:10.20944/preprints202601.0584.v1

4. Discussion

4.1. Grazing Areas

The live-to-dead and leaf-to-stem ratios were higher than those reported by [19] for pastures dominated by *C. plectostachyus* grass in the same study region during the same months as in the present study, where the proportion of live and death herbage was 35:65; while leaf and stem proportion was 25:75. In contrast to the finding of the present study, [20] reported a composition in *C. plectostachyus* pastures associated with *L. leucocephala* cv. Cunningham under humid tropical conditions in southeastern Mexico, using two cutting interval schemes of 30 and 50 days. The leaf-to-stem ratios were 80:20, while the live-to-dead herbage ratio was 90:10. This result represents the potential of this type of pasture under intensive management.

Regarding nutritional composition, the values are within the range reported for pastures dominated by *C. plectostachyus* during the same study period [21,22]. However, the nutritional quality was lower than the values reported by [23,20]; in these two cases, the work was carried out in a sub-humid tropical zone in association with *L. leucocephala*.

4.2. Forage Intake and Diet Composition

Animals exert preferences over the composition of their diet; what they decide to eat depends on the diversity of available forage, the frequency with which certain plants such as trees and shrubs are present, as well as their morphology and nutritional composition [24]. The estimated DMI of the average herd cows was 11.4 (kg of DM/cow), of which 4.5 kg were from supplement and 7.0 kg from forage consumed in the grazing areas. Of the total forage consumed *C. Plectostachyus* accounted for 60%, equivalent to 4.2 (kg of DM/day), *V. farnesiana* 34% or 2.4 (kg of DM/day), and *P. dulce*, *G. ulmifolia*, and *Ficus. sp*., together contributed 420 (g of DM/day) representing 6% of total DMI. This is consistent with the BCP.

Overall, the amount of tree forage consumed was 2.8 (kg DM/day), which was higher than the 1.4 (kg DM/day) reported by [2]. The study by the cited authors was conducted in the same production unit three years after the present study, and throughout the whole dry season (December to May), unlike the present study (March to May). In the study [2], the woody species identified as components of the cows' diet were *V. farnesiana, C. alata, P. dulce*, and *C. pentandra* , which represented 15.8% of the cows' total DMI, which was lower than the 25% tree intake estimated in this study.

Studies have reported that the maximum inclusion level of woody forages without affecting the digestibility of the total diet, as well as the intake and productive performance of the animals, was 30% of the total diet [25,3]. In the present study, in which the cows were free to choose the type of forage consumed, forage from woody species did not exceed this percentage.

In a study [3] with adult cows grazing in a tropical forest known as acahual, reported that the cows' diet during the dry season consisted of 47.5 tree species, with a greater diversity of species consumed compared to the rainy season. However, the nutritional quality of the diet during the rainy season was higher in terms of CP, ADF, lignin, and saponins while during the dry season the diet had a higher content of NDF, as well as condensed tannins.

As the availability and quality of forage in pastures decreased, particularly that of *C. plectostachyus*, as indicated by preference indices, an increase in the preference index for species of the class Magnoliopsida (*P. dulce*, *G. ulmifolia* and *F. sp*.) was observed, although these represented a low percentage of the cows' total DMI. Woody and shrubby plants are sources of protein and energy that also provide other nutrients such as vitamins and minerals during periods of scarcity of conventional forages. In addition, they contain secondary compounds, which improve protein utilization, increase animal productivity, health, and overall animal welfare [26].

In addition to the BCP, the low consumption of species of the class Magnoliopsida may be related to a higher concentration of total phenols, saponins, and aqueous fractions compared to *V. farnesiana*, which could explain the greater consumption of this plant. However, it is also possible that the consumption of various woody plants is a strategy by the animal to minimize the risk of

 doi:10.20944/preprints202601.0584.v1

discomfort caused by consuming this type of forage, as well as to minimize the energy cost of detoxification when consuming forages with secondary compounds [26].

In this regard, the average CP of *V. farnesiana* (228.2 g/kg of DM) was higher than that reported by [27] (159.7 g/kg of DM). Meanwhile, the values for secondary compounds were within the normal range, making this woody species a suitable forage in terms of digestibility and CP content in the diet of cows [28,27].

4.3. Productive Variables of Cows

The mean MY was 5.6 (kg/cow/day), which was lower than the 6.4 (kg/cow/day) reported by [2] and the 6.8 (kg/cow/day) reported by [29], both studies conducted in the same production unit. These differences may be related to the lower mean number of calvings (3.6 ± 1.8) and the average BW (414 kg) of the cows, than of those used in the above-mentioned studies, which reported 4 ± 1.2 calvings and an average BW of 460 (kg/cow).

Milk yields were higher than the 4.3 (kg/cow/day) reported by [30] with Zebu cows of different crosses (Brahman, Gyr, and Guzerat). However, they were lower than the 13.5 and 14.5 (kg/cow/day) reported by [31] Bottini-Luzardo et al. (2016) in Holstein x Brown Swiss x Zebu cross cows grazing in a silvopastoral system with *L. leucocephala* and irrigated *Cynodon nlemfuensis* pastures in southeastern Mexico.

Fat content increased significantly as EP progressed, which may be a result of the interaction between the BCP and the BCD, as well as the presence of rainfall in EP3, where the highest concentrations of milk fat were recorded. Although on average, these levels are within the range reported for cows in the region and on the same PU [32,2]. Higher milk volume is associated with lower concentrations of fat, protein, and lactose, while a smaller milk volume the concentrations of these components increases [33]. Conversely, the concentration of protein in milk decreased significantly. In this regard, it has been reported that heat stress can possibly cause a general decrease in the productive performance of cows, and in particular in the protein content in milk [34].

4.4. Contribution of the Diet to the Nutrient Requirements of the Cows

The forages combined (pasture and woody forages) contributed 63, 48 and 47% of the cows' dry matter, metabolizable energy, and metabolizable protein requirements during the study period. The contribution of nutrients was lower than those estimated for the same production unit during the dry season by [2], who determined that the forages (pasture and trees) contributed with 69, 63 and 60 of the cows' DMI, ME and MP requirements. In the study by [22], the contribution of woody species to dry matter, CP, and ME requirements of the cows were estimated at 20, 7, and 9%, respectively.

5. Conclusions

During the dry season, the quantity and quality of available pastures in grazing areas decrease, so cows increase their intakes of forage from alternative forage resources like woody species such as *V. farnesiana*, and to a lesser extent species such as *Pithecellobium dulce*, *Guazuma ulmifolia* and *Ficus sp*. Together, grasses and woody species contribute 63, 48, and 47% of the cows' dry matter, energy, and metabolizable protein requirements, respectively.

Author Contributions: Conceptualization, B.A.P. and M.G.R.; methodology, F.S.J.P. and B.A.P., software, B.A.P. and A.G.M.; formal analysis, F.S.J.P. and S.E.J.; investigation, F.S.J.P. resources, B.A.P. and M.G.R.; data curation, F.S.J.P. writing—original draft preparation, F.S.J.P., B.A.P. M.G.R.; writing—review and editing, B.A.P. and M.G.R.; supervision, B.A.P. A.G.M. M.G.R. and S.E.J.; All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded partially by Secretariat of Science, Humanities, Technology and Innovation (SECIHTI) of the Mexican government formerly known as CONACYT throughout a Ph.D. scholarship to the

 doi:10.20944/preprints202601.0584.v1

first author; and by the Universidad Autónoma del Estado de México, throughout infrastructure and laboratory support.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of Ethics and Animal Welfare Committee of Centro Universitario UAEM Temascaltepec, Universidad Autónoma del Estado de México. Animals involved in the study were subject to normal farm management, and no experimental procedures were performed in them.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data can be made available from the authors upon request.

Acknowledgments: Authors would like to thank Dra. Antonia González Embarcadero of Universidad Autónoma de Chapingo, for her support to the first author with the microhistological technique training.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Vandermeulen, S.; Ramírez-Restrepo, C.A; Beckers, Y.; Claessens, H.; Bindelle, J. Agroforestry for Ruminants: A Review of Trees and Shrubs as Fodder in Silvopastoral Temperate and Tropical Production Systems. Anim Prod Sci. 2018, 58, 767–77. https://doi.org/10.1071/AN16434
2. Salas-Reyes, I.G.; Estrada-Flores, J.G.; Arriaga-Jordán, C.M.; García-Martínez, A.; Castro-Montoya, J.; Albarran-Portillo, B. Productive Performance of Lactating Brown Swiss Cows Grazing on an Agrosilvopastoral System in a Dry Tropical Region of Mexico : Contribution of Grass , Herbaceous and Woody Species. Agrofor Syst. 2022. 0123456789. https://doi.org/10.1007/s10457-022-00800-4
3. Albores-Moreno, S.; Alayón-Gamboa, J.A.; Miranda-Romero, L.A.; Alarcón-Zúñiga, B.; Jiménez-Ferrer, G .; Ku-Vera, J.C.; Piñeiro-Vázquez, A.T. Effect of Supplementation with Tree Foliage on in Vitro Digestibility and Fermentation, Synthesis of Microbial Biomass and Methane Production of Cattle Diets. Agrofor Syst, 2020. 94, 1469–80. https://doi.org/10.1007/s10457-019-00416-1
4. Sales-Baptista, E.; Ferraz-de-Oliveira, M.I. Grazing in Silvopastoral Systems: Multiple Solutions for Diversified Benefits. Agrofor Syst. 2021, 95, 1–6. https://doi.org/10.1007/s10457-020-00581-8
5. Albarrán-Portillo, B.; Rebollar-Rebollar, S.; García-Martínez, A.; Rojo-Rubio, R.; Avilés-Nova, F.; Arriaga-Jordán, C.M. Socioeconomic and Productive Characterization of Dual-Purpose Farms Oriented to Milk Production in a Subtropical Region of Mexico. Trop Anim Health Prod. 2015, 47, 519–523. https://doi.org/10.1007/s11250-014-0753-8
6. Vandermeulen, S.; Ramírez-Restrepo, C.A.; Marche, C.; Decruyenaere, V.; Beckers, Y.; Bindelle, J. Behaviour and Browse Species Selectivity of Heifers Grazing in a Temperate Silvopastoral System. Agrofor Syst 2018, 92, 705–716. https://doi.org/10.1007/s10457-016-0041-x
7. SMN. Servicio Meteorologico Nacional. Comisión Nacional Del Agua. 2020. Https://Smn.Conagua.Gob.Mx/Es/
8. Wildman, E.E.; Jones, G.M.; Wagner, P.E.; Boman, R.L.; Troutt, H.F.; Lesch, T. N. A Dairy Cow Body Condition Scoring System and Its Relationship to Selected Production Characteristics. J. Dairy Sci. 1982, 65, 495–501. https://doi.org/10.3168/jds.S0022-0302(82)82223-6
9. Powell, J. M.; Wattiaux, M.A.; Broderick, G. A. Short Communication: Evaluation of Milk Urea Nitrogen as a Management Tool to Reduce Ammonia Emissions from Dairy Farms. J. Dairy Sci. 2011, 94, 4690–94. https://doi.org/10.3168/jds.2011-4476
10. Celis-Álvarez, M.D; Arriaga-Jordán, C.M.; González-Ronquillo, M.; Sainz-Ramírez, A.; Flores-Calvete, G.; López-Gonzalez, F. Milk production and nitrogen excretion by dairy cows in late lactation fed cut pastures of different ryegrass – clover species in small-scale dairy systems. Trop. Subtrop Agroecosystems. 2021, 24, 1-10. http://dx.doi.org/10.56369/tsaes.3490
11. Castellaro, G.; Squella, F.; Ullrich, T.; León, F.; Raggi, A. Some Microhistological Techniques Utilized in the Determination of the Botanical Composition of Herbivore Diets. Chil. J. Agr. Res. 2007, 67, 86–93. https://doi.org/10.4067/S0365-28072007000100011

 doi:10.20944/preprints202601.0584.v1

12. González-Embarcadero, A.; Améndola-Massiotti, R.D. Técnica Microhistológica Para La Determinación de La Composición Botánica de La Dieta de Herbívoros. México: Universidad Autónoma Chapingo. 2010.
13. Bryant, F.C.; Taylor, C.A.; Merrill, L.B. White-Tailed Deer Diets from Pastures in Excellent and Poor Range Condition. J. Range Manag. 1981, 34, 193. https://doi.org/10.2307/3898039
14. AOAC. Official Methods of Analysis. 15th Ed., Association of Official Analytical Chemists, Arlington, VA. 1995.
15. Mauricio, R.M.; Mould, F.L.; Dhanoa, M.S.; Owen, E.; Channa, K.S.; Theodorou, M.K. A Semi-Automated in Vitro Gas Production Technique for Ruminant Feedstuff Evaluation. Anim. Feed Sci. Technol. 1999. 79, 321–30. https://doi.org/https://doi.org/10.1016/S0377-8401(99)00033-4
16. AFRC. Energy and Protein Requirements of Ruminants. An Advisory Manual Prepared by the AFRC Technical Committee on Responses to Nutrients. CAB International, Wallingford, UK, 1993.
17. NASEM Dairy-8. National Academies of Sciences, Engineering and Medicine. Nutrient Requirements of Dairy Cattle. Eight Revised Edition. Washington, DC: The National Academies Press. Washington, DC: The National Academies Press, 2021. https://doi.org/10.17226/25806.
18. SAS OnDemand. SAS® OnDemand for Academics. 2025. Https://Welcome.Oda.Sas.Com/Login. https://welcome.oda.sas.com/login.
19. López-González, F.; Estrada-Flores, G.J.; Aviés-Nova, F.; Yong-Angél, G.; Hernández-Morales, P.; Martínez-Loperena, R.; Pedraza-Beltrán, P.E.; Castelán-Ortega, O.A. Agronomic Evaluation and Chemical Composition of Africa Star Grass (Cynodon Plectostacgyus) in the Southern Region Os the State of Mexico." Trop Subtrop Agroecosyst. 2010, 1,: 151–59.
20. Dzib-Castillo, B.; Casanova-Lugo, B.F.; Pozo-Leyva, D.; Costa, R.L.D.; Macario-González, L.; Gimenes, F.M.A.; Lara-Pérez, L.A.; Chay-Canul, A.J. Productivity and Nutritional Quality of Pastures in a Silvopastoral System under Two Harvest Intervals in Southeastern Mexico. Agrofor. Syst. 2025, 99, 137. https://doi.org/10.1007/s10457-025-01235-3
21. López-González, F.; Sánchez-Valdéz, J.J.; Castelán-Ortega, O.A.; Albarrán-Portillo, B.; Estrada-Flores, J.G. Agronomic and Nutritional Characteristics of Three Grass Species in the Southern Region of Mexico. Indian J. Anim. Sci. 2015, 85, 271–74. http://epubs.icar.org.in/ejournal/index.php/IJAnS/article/view/47318
22. Salas-Reyes, I.G. Suplementación energética y determinación de la composición botánica de la dieta de vacas de oble Propósito, en la región sur del Estado de México. Doctorado en Ciencias Agropecuarias y Recursos Naturales. Universidad Autónoma del Estado de México. 2018. http://hdl.handle.net/20.500.11799/99458. https://doi.org/http://hdl.handle.net/20.500.11799/99458
23. Alvarado-Canché, A., Canul-Solis, J.R.; Castillo-Sánchez, L.E., Campos-Naverrete, M.J.; López-Cobá, E.H.; Luna-Mendicuti, A.A.; Ruz-Febles N. Production and Forage Quality of Cynodon Plectostachyus in Silvopastoral Systems with Leucaena Leucocephala. Trop. Subtrop Agroecosyst. 2022. 25
24. Van Soest, P. J. Nutritional Ecology of the Ruminant. Ithaca: Cornell University Press. 1994
25. Ortiz-Rodea, A.; González-Ronquillo, M. López-Villalobos, N.; García-Martínez, A.; Rojo-Rubio, R.; Avilés-Nova, F.; Vázquez-Armijo, J.F.; Albarrán-Portillo, B. Replacement of Lucerne by Enterolobium Cyclocarpum Leaves in the Diet of Growing Goats. Anim. Prod. Sci. 2018. 59, 1293–98. https://doi.org/10.1071/AN16560
26. Mueller-Harvey, I. Unravelling the Conundrum of Tannins in Animal Nutrition and Health †. J. Sci. Food Agric. 2010. 2010–2037. https://doi.org/10.1002/jsfa.
27. Dimas Villalobos, E.; Diana, P.; Torres Velázquez, S.; Delgado, E.; Araiza Rosales, E.E.; Medrano Roldán, H.; Gamero Barraza, J.I.; Pámanes Carrasco, G.A.; Páez Lerma, J.B.; Guerra Rosas, M.I.; Reyes Jáquez, D. In Vitro Evaluation of Cattle Diets with the Inclusion of a Pelletized Concentrate Containing Acacia Farnesiana. Ruminants. 2025. https://doi.org/10.3390/ruminants5040047
28. Ramirez, R.G.; Gonzalez-Rodriguez, H.; Gomez-Mesa, M.V.; Perez-Rodriguez, M.A. Feed Value of Foliage from Acacia Rigidula, Acacia Berlandieri and Acacia Farnesiana. J. Appl. Anim. Res. 1999, 16, 23–32. https://doi.org/10.1080/09712119.1999.9706259.
29. Esparza-Jiménez, S.; Albarrán-Portillo, B.; González-Ronquillo, M.; García-Martínez, A.; Vázquez-Armijo, J.F.; Arriaga-Jordán, C.M. Milk Yield Derived from the Energy and Protein of Grazing Cows Receiving

 doi:10.20944/preprints202601.0584.v1

Supplements under an Agrosilvopastoral System. Rev. Mex. Cienc. Pecu. 2021, 12, 87–104. https://doi.org/10.22319/RMCP.V12I1.5529

30. Pozo-Leyva, D., Casanova-Lugo, F.; López-González, F.; Cruz-Tamayo, A.A.; Costa, R.L.D; Chay-Canúl, A.J. Feed Utilization Efficiency and Nitrogen Balance in Dual Purpose Cows Fed Local Diets in the Subhumid Tropic of Mexico. Chil. J. Agric. Anim. Sci. 2024, 40, 614–622. https://doi.org/10.29393/CHJAAS40-52FUDA60052
31. Bottini-Luzardo, M.B.; Aguilar-Pérez, C.F.; Centurión-Castro, F.G.; Solorio-Sánchez, F.J.; Ku-Vera. J.C. "Milk Yield and Blood Urea Nitrogen in Crossbred Cows Grazing Leucaena Leucocephala in a Silvopastoral System in the Mexican Tropics. Trop. Grassl.-Forrajes Trop. 2016, 4, 159–67. https://doi.org/10.17138/TGFT(4)159-167
32. Morales, C.; Hernández, A.; Hernández Montes, A.; Villegas De Gante, Z.; Aguirre Mandujano, E. El Proceso Socio-Técnico de Producción de Queso Añejo de Zacazonapan, Estado de México. Rev. Mex. Cienc. Pecu. 2011, 2,161–76.
33. Pollott, G.E. Deconstructing Milk Yield and Composition during Lactation Using Biologically Based Lactation Models. J. Dairy Sci. 2004, 87, 2375–87. https://doi.org/10.3168/jds.S0022-0302(04)73359-7.
34. Gao, S.T.; Guo, J.; Quan, S.Y.; Nan, X.M.;.Sanz Fernandez, M.V.; Baumgard, L.H.; Bu, D.P. The Effects of Heat Stress on Protein Metabolism in Lactating Holstein Cows. J.Dairy Sci. 2017, 100, 5040–5049. https://doi.org/10.3168/jds.2016-11913