Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v46i1.62223

RUMINANT NUTRITION

Nutrients intake, milk production, and production costs of dairy goats fed with high proportions of cactus cladodes genotypes *Opuntia* and *Nopalea* in association with different forage sources

José Geraldo Medeiros da Silva[1*], Lázaro Henrique de Medeiros Santos[2], Hildelblano Pereira da Silva[1], Gustavo José Azevedo Medeiros da Silva[1], Daniel Barros Cardoso[3], Guilherme Ferreira da Costa Lima[1] and Airon Aparecido Silva de Melo[3]

[1]Departamento de Produção Animal, Empresa de Pesquisa Agropecuária do Rio Grande do Norte, Av. Eliza Branco Pereira dos Santos, s/n, 59158-160, Parnamirim, Rio Grande do Norte, Brazil. [2]Escola de Ciências Agrárias, Universidade Federal do Rio Grande do Norte, Macaíba, Rio Grande do Norte, Brazil. [3]Departamento de Zootecnia, Universidade Federal do Agreste de Pernambuco, Garanhuns, Pernambuco, Brazil. *Author for correspondence. E-mail: josegeraldomdsilva@gmail.com

ABSTRACT. This study aimed to evaluate the nutrient intake, milk production, and production costs of dairy goats fed diets containing the rations with cactus cladodes (*Opuntia stricta* or *Nopalea cochenillifera*) associated with silage (*Sorghum bicolor*) or Tifton hay (*Cynodon* spp). Twelve pluriparous Saanen and Anglo Nubiana goats (42.25 ± 5.48 kg) at eight weeks of lactation were used. Treatments lasted 60 days, consisting of four periods of 15 days, distributed in three Latin square (4×4) with four diets. The treatments represented by diets with different associated feed: SSOP (Sorghum Silage + *Opuntia*); THOP (Tifton hay + *Opuntia*); SSNO (Sorghum Silage + *Nopalea*); and THNO (Tifton hay + *Nopalea*), in addition to concentrate in all diets. There were differences ($p < 0.05$) for the intakes of DM, OM, with higher values observed for goats fed the diets THNO, THOP, and SSNO, and for CP, NDF and ADF were higher for THNO and SSNO diets. Similar behavior occurred for voluntary and total water intake. The milk production and feed efficiency did not differ ($p > 0.05$). Costs with food, milk revenue, and gross revenue were not influenced by diets ($p > 0.05$). The *Opuntia* or *Nopalea* cactus cladodes genotypes associated with sorghum silage or tifton hay can be used to feed dairy goats in the semiarid region.

Keywords: forage conservation; non-fibrous carbohydrates; semiarid; water intake.

Received on January 24 2022.
Accepted on October 4 2022

Introduction

In livestock production systems in the Brazilian semiarid region, dairy goat farming has the Caatinga vegetation as the main forage support, which presents the low qualitative and quantitative forage production as the biggest problem affecting voluntary consumption, energy density, milk production. With the farms extremely dependent on commercial concentrates in the dry period, and consequently high diet costs (Lopes et al., 2017).

In certain locations of the Caatinga biome, forage cactus is an excellent food option for feeding dairy goats, especially during periods of severe drought (Costa et al., 2009). In recent years, about genotypes (*Opuntia stricta*; *Nopalea cochenillifera*) due to its resistance to carmine scale (*Dactylopius* sp), high yields (Ben Salem, 2010; Edvan et al., 2020), and concentrations of non-fibrous carbohydrates (Carneiro, Ramos, Pimenta Filho, & Moura, 2015; Catunda et al., 2016; Lopes et al., 2017), they are being used as roughage in the composition of dairy goats' diet (Góes Neto et al. 2021). However, these forages have low concentrations of dry matter (DM) of 83.0 - 139.8 g kg^{-1} of natural matter, neutral detergent fiber (NDF) of 359.0 - 449.0 g kg^{-1} of DM, and crude protein (CP) of 46.0 - 949.0 g kg^{-1} of DM, requiring their association in the animal diet with foods rich in fiber and protein (Ben Salem, 2010; Andrade-Montemayor, Cordova-Torres, García-Gasca, & Kawas, 2011; Edvan et al., 2020).

About cactus cladodes and other cacti in the feeding of small ruminants, Ben Salem (2010) reported the importance of these forages as a water supply via food for sheep and goats in semiarid regions. When feeding Saanen goats, Góes Neto et al. (2021) observed a 40 to 60% reduction in water intake due to the 50% participation in DM of the genotypes (*Nopalea cochenillifera*; *Opuntia stricta*) and other cacti in the experimental diets.

The production of introduced and adapted forage species during the rainy season, and their conservation as silage and/or hay has been used in the dry period as options for strengthening livestock production systems in semiarid regions (Ramos et al., 2020; Santos, Silva, Dubeux Júnior, Lira, & Silva, 2013). In this context, sorghum silage and Tifton hay have been used in the animal diet as food with good nutritional value (Ramos et al., 2020; Sousa et al., 2018).

Forage quality represents the most important factor in the response of lactating goats when they are fed rations containing the fiber of origin, with varied quality (Branco et al., 2011). According to Van Soest, Robertson, and Lewis (1991), the type and amount of fibrous and non-fibrous carbohydrates (NFC) affect fermentation and microbial efficiency, since the proportions of crude protein, ether extract, and ash are relatively constant in dairy cows' diets. The balance of rations is between NDF or NFC. Ben Salem, Nefzaoui, and Orskov (1996) reported that the level of cactus participation in a diet can reach 55% of DM and that supplementing cactus-based diets with fibrous foods can prevent digestive disorders by improving microbial activity in the rumen.

The performance of crossbred goats (Saanen x Alpina Americana) on composite diets based on DM by 46% of a genotype (Orelha de Elefante Mexicana (OEM), Bahia (*Nopalea* sp) or Miúda) associated with Tifton hay, Fernandes et al. (2021) reported that there was no difference between diets for milk production, with a daily mean value of 2.6 kg. Soares, Correia, Souza, Carvalho, and Maciel (2020) using Saanen goats and studying diets with Orelha de Elefante Mexicana (OEM) substituting up to 35% for Miúda cactus cladodes, presented DM intake with a daily mean value of 2.6 kg and milk production of 3.3 kg. With Anglo Nubian goats, Ramos et al. (2020) working with 30% of the genotype (*Nopalea cochenillifera*), with sorghum silage or buffel hay, presented mean daily milk production values with 1.5 kg silage and 1.7 kg hay, which did not differ from each other.

This research aimed to evaluate the nutrient intake, milk production and production costs of goats fed diets containing the genotypes of cactus cladodes (*Opuntia stricta* or *Nopalea cochenillifera*) associated with silage (*Sorghum bicolor*) or hay (*Cynodon* spp).

Material and methods

Ethics Committee on the Use of Animals (CEUA) of the Universidade Federal do Rio Grande do Norte (UFRN) - PROTOCOL No. 081/2019.

The experiment was conducted at the Experimental Station of Cruzeta - RN, Brazil, belonging to the Agricultural Research Corporation of Rio Grande do Norte (EMPARN). Cruzeta city is located at the following geographical coordinates: 6° 26' south latitude and 36° 35' west longitude of Greenwich and 230m average altitude. The climate, according to the Koppen classification, is the type BSs`h semiarid. According to the National Institute of Meteorology (INMET, 2020), the mean temperature and relative humidity and total rainfall in the trial were 29.2°C; 61.8% e 83.3 mm, respectively.

Twelve Saanen and Anglo-Nubian goats pluriparous at eight weeks of lactation and an average live weight of 42.25 kg ± 5.48 kg were used. The animals were distributed in a Latin square design (4x4) with four goats, four experimental diets, and four periods. The experiment was performed in pens with a cement floor, consisting of twelve stalls, each measuring 1m wide by 3 m long, with partitioned wooden fences and indoor areas covered with ceramic roof tiles. Feeders (plastic drum with a capacity of 50 kg) and a plastic bucket for drinking (12.0-liter capacity) were individual and located outside the stalls.

The study lasted 60 days, with four consecutive experimental periods of 15 days, 10 days for adaptation, and 5 days for each collection period. The animal weighing was performed at the beginning and end of the introduction period and every 15 days until the end of the trial. The diets were formulated to meet the daily milk production requirements of 1.5 kg assuming 42 kg goats as the average weight according to the nutritional requirements of the National Research Council (NRC, 2007).

The cladodes from the introduced cacti were harvested from cultivated and irrigated areas. The cacti cladodes were hand-cut with a knife at feeding time. The food was offered twice a day at 7:00 a.m. (500.0g kg^{-1}) and at 4:00 p.m. (500.0g kg^{-1}), consisting of a mixture of one of the cacti, silage or hay, ground corn, soybean meal, and minerals to form a total mixed ration. A 10% leftover of the total dry matter was allowed.

The treatments were defined based on dry matter, being composed of: 559.0 to 603.0 g kg^{-1} of the cacti, prickly pear cactus cv. miúda (*Nopalea*) and *Opuntia* cv. orelha de elefante mexicana (*Opuntia*), 201.0 to 214.0 kg^{-1} (*Sorghum bicolor* silage or *Cynodon* spp hay) and 194.0 to 230.0 g kg^{-1} of concentrate (composed of ground corn, soybean meal, and mineral mix) recommended for lactating goats (Tables 1 and 2).

Table 1. Chemical composition of ingredients of the experimental diets.

Components(1)	Ingredients					
	Opuntia	*Nopalea*	Sorghum Silage	Tifton Hay	Ground Corn	Soybean meal
DM[1]	112.1	132.3	239.8	847.3	831.4	838.1
OM[2]	766.5	761.8	909.1	895.9	983.2	930.7
CP[2]	36.2	52.5	72.0	61.9	79.7	463.6
EE[2]	23.4	19.8	11.7	08.1	32.3	26.6
NDF[2]	227.7	286.4	703.2	749.3	268.0	140.0
ADF[2]	123.5	191.7	426.2	378.6	26.9	112.9
TC[2]	706.9	689.6	825.3	825.9	871.2	440.5
NFC[2]	479.2	403.1	122.0	76.5	402.6	275.5
Cust (R$ Kg DM^{-1})	1.25	1.28	1.46	1.18	2.00	3.34

[1)]g kg^{-1} fresh matter (NM), [2]g kg^{-1} DM, DM = dry matter, OM = organic matter, CP = crude protein, EE = ether extract, NDF = neutral detergent fiber, ADF = acid detergent fiber, TC = total carbohydrates, NFC = non-fibrous carbohydrates.

Table 2. Proportions of ingredients in the diets.

Item	Diets			
	SSOP	THOP	SSNO	THNO
Cactus cladodes	559.0	566.2	603.8	598.9
Sorghum silage	210.1	-	201.1	-
Tifton hay	-	214.1	-	206.2
Corn	106.4	107.0	99.3	102.3
Soybean	85.2	86.2	80.0	81.2
Mineral mix	39.3	26.5	15.8	11.4
Composition (g kg^{-1})				
DM[1]	312.3	432.4	299.3	418.3
OM[2]	803.3	811.2	814.7	816.9
CP[2]	83.1	82.0	90.9	89.8
EE[2]	21.0	20.5	19.2	18.8
NDF[2]	315.3	329.9	352.1	364.7
ADF[2]	170.9	163.4	213.0	204.6
TC[2]	698.5	708.1	703.9	708.1
NFC[2]	359.6	354.3	349.1	320.5

SSOP = Sorghum Silage + *Opuntia*; THOP = Tifton Hay + *Opuntia*; SSNO = Sorghum Silage + *Nopalea*; THNO = Tifton Hay + *Nopalea*. [(1)]g kg^{-1} fresh matter. [2]g kg^{-1} DM, DM = dry matter, OM = organic matter, CP = crude protein, EE = ether extract, NDF = neutral detergent fiber, ADF = acid detergent fiber, TC = total carbohydrates, NFC = non- fibrous carbohydrates.

To obtain the nutrient intake and chemical analysis, the samples were collected weekly during the adaptation period and daily in the collection period. Samples consisted of the ingredients offered in diets: *Nopalea*, *Opuntia*, *Sorghum* silage, Tifton hay, corn, and soybean; as well as the leftover food left by each animal, sampled daily to obtain a composite sample of the experimental period (weekly).

In the laboratory, the samples were pre-dried in a forced ventilation oven at 55°C, prepared for chemical analysis for chemical composition through the Association of Official Analytical Chemists (AOAC, 1997) methods, to determine dry matter (DM, method 934.01), ask (method 942.05), organic matter (OM, method 930.05), crude protein (CP, Kjeldahl N × 6.25, method 981.10), and ether extract (EE, method 920.39). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest, Robertson, and Lewis (1991).

The total carbohydrates (TC) were calculated according to Sniffen, O'Connor, Van Soest, Fox, and Russell (1992) where TC = 100 - (% CP + % EE + % Ash). Non-fibrous carbohydrates (NFC) were calculated according to the equation described by Hall, Hoover, Jennings, and Webster (1999) where NFC = % TC - % NDF.

The goats were hand milked at 6 a.m. and 3 p.m. Individual milk production was quantified with milk samples being collected twice a day, once per week in the adaptation period, and at each of the five days during the collection period. Milk production was evaluated by daily control and 4%-fat-corrected milk by the equation suggested by the National Research Council (NRC, 2001).

The cost of total feeding (CT) was estimated by the value of dry matter intake during the 60 experimental days. The milk revenue (RM) was estimated by the relationship of milk production and the selling price at the end of the experiment. Thus, the gross profit (GP) was estimated by the equation: GP = CT – RM; the gross margin (GM) was estimated by the equation: GM = (GP/RM)*100. The cost of feed per day concerning milk production was also calculated.

Data were submitted to analysis of variance and comparison of means by Tukey test, using the SAS program (Statistical Analysis System [SAS], 2002) version 9.0.

Results and discussion

There was a difference ($p < 0.05$) in the dry matter intake (DMI) expressed in g day^{-1}, % of body weight (BW), and g kg$^{-0.75}$ between the experimental diets. The DMI with Tifton hay and *Nopalea* genotype (THNO), Tifton hay and *Opuntia* (THOP), and sorghum silage and *Nopalea* (SSNO) were higher than with the sorghum silage and *Opuntia* genotype (SSOP) (Table 3).

Table 3. Nutrient intake of goats fed with cactus cladodes genotypes Orelha de Elefante Mexicana or Miúda.

Item	Diets				SEM	*P*-value
	SSOP	THOP	SSNO	THNO		
DMI (g)	1350.11b	1445.95ab	1513.88ab	1618.34a	55.82	0.049
DMI (%BW)	3.23b	3.44ab	3.61ab	3.84a	0.016	0.012
DMI (g kg$^{-0.75}$)	81.52b	87.63ab	91.79ab	97.96a	3.137	0.044
OMI (g)	1102.74b	1186.52ab	1224.59ab	1354.77a	45.41	0.004
OMI (%BW)	2.65b	2.78ab	2.92ab	3.10a	0.092	0.020
OMI(g kg$^{-0.75}$)	66.62b	71.94ab	74.25ab	80.75a	2.566	0.028
CPI (g)	120.85c	125.55bc	141.94ab	155.36a	4.426	0.001
CPI (%BW)	0.28b	0.29b	0.33a	0.36a	0.009	<.0001
CPI (g kg$^{-0.75}$)	66.62b	71.94ab	74.25ab	80.75a	0.253	0.001
NDFI (g)	412.64c	466.98bc	513.58ab	571.24a	20.47	0.001
NDFI (%BW)	0.98c	1.10bc	1.22ab	1.33a	0.043	0.001
NDFI (g kg$^{-0.75}$)	24.71c	28.30bc	31.16ab	34.49a	1.169	0.001
ADFI (g)	228.17b	232.16b	307.92a	320.33a	11.94	<0001
ADFI (%BW)	0.54b	0.54b	0.73a	0.75a	0.025	<.0001
ADFI (g kg$^{-0.75}$)	13.80b	13.22b	18.68a	19.35a	0.758	<.0001
EEI (g)	30.77	31.45	30.15	32.10	1.127	0.240
TCI (g)	978.06	1033.96	1044.71	1130.03	39.66	0.089
NFCI (g)	507.41	518.05	502.33	514.85	20.68	0.612

SSOP = Sorghum Silage + *Opuntia*; THOP = Tifton Hay + *Opuntia*; SSNO = Sorghum Silage + *Nopalea*; THNO = Tifton Hay + *Nopalea*; DMI = Dry matter intake; OMI = organic matter intake; CPI = crude protein intake; NDFI = neutral detergent fiber intake; ADFI = acid detergent fiber intake; EEI = ether extract intake; TCI = total carbohydrate intake; NFCI = non-fibrous carbohydrates intake; SEM = standard error of the mean; Means followed by different letters in the lines differ ($p < 0.05$) by the Tukey test.

The DM intakes in this research corroborate with Ramos et al. (2020) working with Anglo Nubiana goats and Miúda cladodes cactus when they reported higher DM intakes in the buffel hay diet (1855 g), concerning the sorghum silage diet (1253 g). This result can be attributed to DM differences in quantity, and or, quality of food in the diets (Table 2). Particularly with the *Opuntia* diet and silage, the lowest intake was probably due to the presence of tannins in the sorghum silage (Ramos et al., 2020). The DM intake values of the diets with cactus cladodes cactus Miúda in the current research were higher than Pereira et al. (2021) with Anglo Nubiana goats and Miúda cactus cladodes (1502.69 g) and Silva, Melo, Rêgo, Lima and Aguiar (2011) with Saanen goats, native cacti and 'flor de seda' hay (1152.62 g).

There was a difference ($p < 0.05$) between the diets for organic matter intake (OMI), with higher values observed for goats, fed the diets THNO, THOP, and SSNO (Table 3). The difference for OM intake can be explained in part by the similar behavior for DM intake.

The crude protein intake (CPI) was influenced by diets ($p < 0.05$; Table 3), with higher values for animals fed with THNO and SSNO. However, all diets had CP intakes below the recommended by the NRC (2007), of 0.211 kg day^{-1}. These reduced CP intakes in the present research can be explained by the low CP values in the chemical composition of cactus cladodes genotypes (Table 1), as well as their high proportions in the diets (Table 2), consequently the low intake of this nutrient by the animals.

The intakes of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were higher for animals fed with THNO and SSNO ($p < 0.05$). While the intake of EE, TC, and NFC did not differ ($p > 0.05$; Table 3). This result may be related to differences in NDF concentrations in the diets (31.53 to 36.47%), and thus justify the differences in NDF intakes by the goats. Mertens (1987) recommended the mean value of 1.25% of animal weight to express the optimal NDF intake in the ratio of lactating animals. Van Soest (1965) suggested that the fiber content of the food limit intake when the proportions of these constituents increase in the diet, thus increasing the intake precluded by the volume occupied by the fibrous mass, exerting a physical effect of ruminal filling. Based on milk production, DM, fiber, and energy intake, Branco et al. (2011) defined levels of 35% of NDF from forage (NFDf), as the concentration where the best efficiency in the use of forages in the diet of dairy goats would be obtained. All diets had NDF contents within minimum limit of 25% of dietary fiber, necessary for production and animal health (Mertens, 1997).

Goats have anatomical and physiological variations that differentiate them from cattle. They have larger salivary glands, smaller rumen about body weight and anatomy to capture foods that favors the selection of more digestible foods (Van Soest, 1994). These differences can make goats more tolerant to the use of diets with low effective fiber content and high concentrations of NFC (Sousa et al., 2018).

Mertens (1997) reported that cows fed rations with the same NDF concentration may not have the same intake and that the relationship between NDF and intake also depends on the animal's demand curve. However, the point at which the NDF level in the diet no longer physically limits consumption is determined by the level of animal production. However, goats have a shorter retention time of particles in the rumen than that of cattle, which can determine greater ingestion capacity (Van Soest, 1994). In this research, although NDF intakes differed between diets, there was no influence on the milk production of goats.

As with the NDF intake, the ADF intake of the *Nopalea* containing diet was higher than the *Opuntia* due to the higher ADF concentrations in the *Nopalea* diets (Table 2).

The diets did not differ in terms of ($p > 0.05$) water intake via food, with an average of 7521.88 g day^{-1} (Table 4). This result corroborates with Góes Neto et al. (2021) when they presented a mean value of 7050.19 g day^{-1} in water intake via feed, due to the participation of 50% of the genotypes of cactus cladodes Orelha de Elefante Mexicana (OEM), and Miúda and other cacti in diets with Saanen goats.

Table 4. Natural matter intake and water by goats fed with cactus cladodes genotypes Orelha de Elefante Mexicana or Miúda.

Item	Diets				SEM	*P*-value
	SSOP	THOP	SSNO	THNO		
NMI (g)	9019.6	8575.8	9333.6	9086.9	370.5	0.915
WIF (g)	7669.5	7129.8	7819.7	7468.6	329.8	0.833
VWI (g)	1132.8b	1405.3ab	2007.2a	2041.3a	232.1	0.012
TWI (g)	8802.3ab	8531.1b	9826.9a	9509.9ab	341.1	0.179

SSOP = Sorghum Silage + *Opuntia*; THOP = Tifton Hay + *Opuntia*; SSNO = Sorghum Silage + *Nopalea*; THNO = Tifton Hay + *Nopalea*; NMI = natural matter intake; WIF = water intake from feed; VWI = voluntary water intake; TWI = total water intake; SEM = standard error of the mean; Means followed by different letters in the lines differ ($p < 0.05$) by the Tukey test.

There was an effect of diets on voluntary water intake (VWI) ($p < 0.05$) between diets and total water intake (TWI). Where goats fed the THNO, THOP and SSNO diets presented higher values for VWI, while the TWI was higher for SSNO, SSOP, and THNO diets (Table 4). This result is in agreement with (Góes Neto et al., 2021; Silva et al., 2011; Pereira et al., 2021; Ramos et al., 2020) using Saanen and Anglo Nubiana goats fed OEM, Miúda and native cacti.

Although the OEM and Miúda forage cactus genotypes present high concentrations of water in their cell contents, the animals also sought water in the drinking fountain, which may be related to the diuretic effect of the cacti. On the other hand, ruminants have the ability, after being satisfied, to ingest more water to store it (Misra & Singh, 2002).

It is noteworthy in this research that the natural matter intake did not differ ($p > 0.05$) between diets with a mean value of 9003.95 g day^{-1} (Table 4). Thus, the addition of water by itself in the rumen has little effect on the intake; however, water retained in a structural component of ingested forage can limit the intake (Van Soest, 1994). Probably the high volume of cactus cladodes (55.90 to 60.38%) contained in the diets regulated the NM intake.

There was no difference ($p > 0.05$) between diets for milk production corrected to 4% fat with a daily mean value of 1217.03g (Table 5). This result can be explained by the balance of NDF (31.53 to 36.47%) or NFC (32.05 to 35.96%) of the diets, which, according to Mertens (2001), are necessary for the production of milk for infants. The fractionation of carbohydrates in dairy cows' diets is mainly necessary, due to the peculiarity in the fermentation of each fraction and its interference in feed intake, and milk production (Sniffen et al., 1992). In this research, the interaction between NDF and NFC contained in the diets probably promoted adequate fermentation, due to the physical effects of the fiber, causing greater chewing, ensuring the maintenance of normal rumen conditions, and consequently milk production (Van Soest, 1994; Mertens, 2001).

The production of milk from goats may also have occurred due to the concentration of NFC consumed by the animals, receiving high proportions (55.90 to 60.38%) of the cacti, and consequently due to the greater input of energy. In general, the increase in the concentration of NFC (Van Soest, 1994) in the diets, results in greater metabolizable energy intake, microbial protein flow, and, consequently, greater milk production.

Table 5. Milk production and feed efficiency by goats fed cactus cladodes genotypes Orelha de Elefante Mexicana or Miúda.

Item	Diets				SEM	*P*-value
	SSOP	THOP	SSNO	THNO		
FCM (g day^{-1})	1124.97	1209.93	1275.25	1257.98	73.18	0.369
FE (Kg L $KgDM^{-1}$)	0.87	0.83	0.85	0.80	0.047	0.547

SSOP = Sorghum Silage + *Opuntia*; THOP = Tifton Hay + *Opuntia*; SSNO = Sorghum Silage + *Nopalea*; THNO = Tifton Hay + *Nopalea*; FCM = 4% fat-corrected milk; FE = food efficiency; SEM = standard error of the mean; Means followed by different letters in the lines differ (P<0.05) by the Tukey test.

Góes Neto et al. (2021) in research with Saanen goats (50 kg) fed with the genotypes cactus cladodes OEM, Miúda, and native cacti associated with 'Sabiá' hay in the diets, also observed no difference in milk production with a daily average of 1.9 kg. In another research with Anglo Nubiana goats (43 kg), Pereira et al. (2021) used 40% buffel hay and replaced 100% of corn (*Nopalea cochenillifera*), reported a mean daily milk production value of 997g. With Saanen x Pardo Alpina goats (47 kg), Goveia et al. (2016) using 45% gliricidia hay (*Gliricidia sepium* (Jacq) Walp) and replacement of up to 72% ground corn for Miúda cactus cladodes, reported an average daily milk production value of 1.18 kg. However, several aspects must be taken into account for these differences: size and age of goats, level of production, quantity, and quality of forage in the diets, among others.

The results of milk production in this work, regarding the research presented by Pereira et al. (2021), Ramos et al. (2020), Sousa et al. (2018), Lopes et al. (2017), and Goveia et al. (2016) highlight the possibility that the producer has, in certain semi-arid areas of northeastern Brazil, two genotypes of cactus cladodes resistant to carmine scale, with a forage/concentrate ratio of 80:20, and a reduction of water via food above 78% in all diets, contributing to less dependence on the concentrate feed market.

Cost of diet, the revenue of milk, cost of diet per day about milk production, gross profit, and gross margin were not influenced (p > 0.05) by diets (Table 6). Soares et al. (2020) observed a reduction in production costs with the feeding of dairy goats fed with the Miúda or OEM genotypes.

Table 6. Milk production costs of goats fed with cactus cladodes genotypes Orelha de Elefante Mexicana or Miúda.

Item	Diets				SEM	*P*-value
	SSOP	THOP	SSNO	THNO		
Daily values						
Cost of diet (R$ kg^{-1})	1.79	1.66	1.65	1.57	-	-
Price of milk (R$)	3.00	3.00	3.00	3.00	-	-
Daily feed cost (kg day^{-1})	2.35	2.43	2.52	2.51	0.088	0.694
Revenue of milk (R$ day^{-1})	3.70	3.97	4.22	4.03	0.181	0.215
Cost of diet /MP (R$)	2.74	2.21	2.36	2.58	0.074	0.583
Gross profit (R$)	1.35	1.54	1.70	1.52	0.145	0.193
Total values						
Cost of diet (kg)	140.87	145.56	150.97	150.64	5.246	0.693
Revenue of milk (R$)	222.21	238.27	253.38	241.87	10.77	0.213
Gross profit (R$)	81.38	92.61	102.41	91.23	8.634	0.198
Gross margin (%)	34.23	35.28	37.28	34.40	2.482	0.556

SSOP = Sorghum Silage + *Opuntia*; THOP = Tifton Hay + *Opuntia*; SSNO = Sorghum Silage + *Nopalea*; THNO = Tifton Hay + *Nopalea*; MP = Milk production; SEM = standard error of the mean; Means followed by different letters in the lines differ (p < 0.05) by the Tukey test.

Conclusion

The *Opuntia* or *Nopalea* cactus cladodes genotypes associated with sorghum silage or tifton hay can be used to feed dairy goats in the semiarid region.

References

Andrade-Montemayor, H. M., Cordova-Torres, A. V., García-Gasca, T., & Kawas, J. R. (2011). Alternative foods for small ruminants in semiarid zones, the case of Mesquite (*Prosopis laevigata* spp.) and Nopal (*Opuntia* spp.) *Small Ruminant Research*, *98*(1-3), 83-92. DOI: https://doi.org/10.1016/j.smallrumres.2011.03.023

Association of Official Analytical Chemists [AOAC]. (1997). *Official Methods of Analysis* (16th ed.). Arlington, VA: AOAC.

Ben Salem, H., Nefzaoui, A., & Orskov, E.R. (1996). Effect of increasing level of spinelles cactus (*Opuntia fícus indica* var. inermis) on intake and digestion by sheep given straw-based diets. *Animal Science*, *62*(2), 293-299. DOI: https://doi.org/10.1017/S1357729800014600

Ben Salem, H. (2010). Nutritional management to improve sheep and goat performances in semiarid regions. *Revista Brasileira de Zootecnia*, *39*, 337-347. DOI: https://doi.org/10.1590/S1516-35982010001300037

Branco, R. H., Rodrigues, M. T. R., Silva, M. M. C., Rodrigues, C. A. F., Queiroz, A. C., & Araújo, F. L. (2011). Desempenho de cabras em lactação alimentadas com dietas com diferentes níveis de fibra oriundas de forragem com maturidade avançada. *Revista Brasileira de Zootecnia*, *40*(5), 1061-1071. DOI: https://doi.org/10.1590/S1516-35982011000500018

Carneiro, W. P., Ramos, J. P. F., Pimenta Filho, E. C., & Moura, J. F. P. (2015). Utilização de Carboidratos não Fibrosos na Alimentação de Cabras Leiteiras: Composição e Perfil Lipídico. *Revista Científica de Produção Animal*, *17*, 50-60. DOI: https://doi.org/10.15528/2176-4158/rcpa.v17n1p50-60

Catunda, K. L. M., Aguiar, E. M., Góes Neto, P. E., Da Silva, J. G. M., Moreira, J. A., Rangel, A. H. N., & Lima Júnior, D.M. (2016). Gross composition, fatty acid profile and sensory characteristics of Saanen goat milk fed with Cacti varieties. *Tropical Animal Health and Production*, *48*(5), 1253-1259. DOI: https://doi.org/10.1007/s11250-016-1085-7

Costa, R. G., Beltrão Filho, E. M., Medeiros, A. N., Givisiez, P. E. N., Queiroga, R. C. R. E., & Melo, A. A. S. (2009). Effects of increasing levels of cactus pear (*Opuntia ficus-indica* L. Miller) in the diet of dairy goats and its contribution as a source of water. *Small Ruminant Research*, *82*, 62-65. DOI: https://doi.org/10.1016/j.smallrumres.2009.01.004

Edvan, R. L., Mota, R. R. M., Dias-Silva, T. P., Nascimento, R. R., Sousa, S. V., Silva, A. L., … Araújo, J. S. (2020). Resilience of cactus pear genotypes in a tropical semi-arid region subject to climatic cultivation restriction. *Scientific Reports*, *10*(10040), 1-10. DOI: https://doi.org/10.1038/s41598-020-66972-0

Fernandes, B. D. O., Queiroga, R. C. R. E., Costa, R. G., Silva, D. S., Maciel, M. L., Ramos, A. O., & Medeiros, A. N. (2021). Spineless cactus varieties resistant to carmine cochineal (*Dactylopius sp*.) on the composition and sensory properties of goat Milk. *Acta Scientiarum. Animal Sciences, 43*, e47873. DOI: https://doi.org/10.4025/actascianimsci.v43i1. 47873

Góes Neto, P. E., Silva, J. G. M., Aguiar, E. M., Melo, A. A. S., Lima, G. F. C., Cardoso, D. B., & Silva, H. P. (2021). Native and introduced forage cacti in Saanen dairy goat diets. *Acta Scientiarum. Animal Sciences, 43*, e51029. DOI: https://doi.org/10.4025/actascianimsci.v43i1.51029

Goveia, J. S. S., Oliveira, V. S., Santos, G. R. A., Melo, K. D. A., Oliveira, A. G., & Melo, M. V. A. (2016). Partial replacement of corn byforage cactus in the diets of lactating goats. *Semina: Ciências Agrárias*, *37*(2), 969-976. DOI: https://doi.org/105433/1679-0359.2016v37n2p969

Hall, M. B., Hoover, W. H., Jennings, J. P., & Webster, T. K. M. (1999). A method for partitioning neutral detergent soluble carbohydrates. *Journal of the Science of Food and Agriculture*, *79*(15), 2079-2086. DOI: https://doi.org/10.1002/(SICI)1097-0010(199912)79:15<2079:AID-JSFA502>3.0.CO;2-Z

Instituto Nacional de Meteorologia [INMET]. (2020). *Mapa de Observações Meteorológicas Mensais*. Brasília, DF: INMET. Retrieved from http://www.inmet.gov.br/portal/index.php?r=estacoes/estacoesautomaticas

Lopes, L. A., Carvalho, F. F. R., Cabral, A. M. D., Batista, Â. M. V., Camargo, K. S., Silva, J. R. C., & Silva, J. (2017). Replacement of tifton hay with alfalfa hay in diets containing spineless cactus (*Nopalea cochenillifera* Salm-Dyck) for dairy goats. *Small Ruminant Research*, *156*, 7-11. DOI: https://doi.org/10.1016/j.smallrumres.2017.08.006

Mertens, D. R. (1987). Predicting intake and digestibility using mathematical models of ruminal function. *Journal of Dairy Science*, *64*(5), 1548-1558.

Mertens, D. R. (1997). Creating a system for meeting the fiber requirements of dairy cows. *Journal of Animal Science*, *80*, 1463-1481. DOI: https://doi.org/10.3168/jds.S0022-0302(97)76075-2

Misra, A. K., & Singh, H. (2002). Effect of water deprivation on dry matter intake, nutrient utilization and metabolic water production in goats under semi-arid zone of India. *Small Ruminant Research*, *46*(2-3), 159-165.

National Research Council [NRC]. (2001). *Nutrient Requirements of Dairy Cattle* (7th ed.). Washington, DC: National Academy Press.

National Research Council [NRC]. (2007). *Nutrient requirements of small ruminants: sheep, goats, cervids, and new world camelids* (7th ed.). Washington, DC: National Academy Press.

Pereira, G. F., Neto, J. V. E., Gracindo, A. P. A. C., Silva, Y. M. O., Difante, G. S., Gurgel, A. L. C., ... Lima, G. F. C. (2021). Replacement of grain maize with spineless cactus in the diet of dairy goats. *Journal of Dairy Research*, *88*(2), 134-138. DOI: https://doi.org/10.1017/S0022029921000352

Ramos, J. P. F., Sousa, W. H., Oliveira, J. S., Pimenta Filho, E. C., Santos, E. M., Leite, R. M., ... Oresca, D. (2020). Forage sources in diets for dairy goats. *Acta Scientiarum. Animal Sciences*, *41*, e46084. DOI: https://doi.org/10.4025/actascianimsci.v42i1.46084

Santos, D. C., Silva, M. C., Dubeux Júnior, J. C., Lira, M. A., & Silva, R. M. (2013). Estratégias para uso de cactáceas em zonas semiáridas: novas cultivares e uso sustentável das espécies nativas. *Revista Científica de Produção Animal*, *15*(2), 111-121. DOI: https://doi.org/10.15528/2176-4158/rcpa.v15n2p111-121

Silva, J. G. M., Melo, A. A. S., Rêgo, M. M. T., Lima, G. F. C., & Aguiar, E. M. (2011). Cactáceas nativas associadas a fenos de flor de seda e sabiá na alimentação de cabras leiteiras. *Revista Caatinga*, *24*(2), 158-164. Retrieved from https://periodicos.ufersa.edu.br/index.php/caatinga/article/view/1914

Sniffen, C. J., O'Connor, J. D., Van Soest, P. J., Fox, D. G., & Russell, J. B. (1992). A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. *Journal of Animal Science*. *70*(11), 3578–3596. DOI: https://doi.org/10.2527/1992.70113578x

Statistical Analysis System [SAS]. (2002). *User's Guide, Version* 9.0. Cary, NC, SAS.

Sousa, N. M., Oliveira, J. S., Silva, D. S., Santos, E. M., Medeiros, A. N., Ramos, J. P. F., & Brito, E. A. (2018). Levels of neutral detergent fiber in diets with forage palm for dairy goats. *Arquivo Brasileiro de Medicina Veterinária de Zootecnia*, *70*(5), 1595-1604. DOI: https://doi.org/10.1590/1678-4162-10181

Soares, L. F. P., Correia, A. M. N., Souza, A. F., Carvalho, F. F. R., & Maciel, M. V. (2020). Milk production and the feeding costs of lactating Saanen goats fed diets containing spineless cactus. *Revista Caatinga*, *33*(2), 550-554. DOI: https://doi.org/10.1590/1983-21252020v33n227rc. Retrieved from https://periodicos.ufersa.edu.br/index.php/caatinga/article/view//1914

Van Soest, P. J. (1965). Symposium on factors influencing the voluntary intake of herbage by ruminants: Voluntary intake relation to chemical composition and digestibility. *Journal of Animal Science*, *24*(3), 834-844.

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74*(10), 3583-3597. DOI: https://doi.org/10.3168/jds.S0022-0302(91)78551-2

Van Soest, P. J. (1994). *Nutritional ecology of the ruminant* (v. 1). Ithaca, NY: Cornell University Press.