The addition of three different levels of cactus pear (*Opuntia ficus-indica*) to the diet of Holstein cows and its effect on milk production in the dry season

Rosa Elena Pérez-Sánchez*[1], José Luis Mendoza-Ortíz[2], Hector Eduardo Martínez-Flores[3], y Ruy Ortiz-Rodríguez[4]

[1] Facultad de Agrobiología "Presidente Juárez", Universidad Michoacana de San Nicolás de Hidalgo. Paseo Lázaro Cárdenas-Berlín Col. Viveros. Uruapan Michoacán, México.
[2] Instituto de Investigaciones Agropecuarias y Forestales, Universidad Michoacana de San Nicolás de Hidalgo.
[3] Facultad de Químico Farmacobiología, UMSNH. Morelia, Michoacán**,** México.
[4] Facultad de Medicina Veterinaria y Zootecnia, Universidad Michoacana de San Nicolás de Hidalgo, km 9.5 Carretera Morelia-Zinapécuaro. Tarímbaro Michoacán, México. CP 58880.

*Corresponding Author: rosa_elenap@yahoo.com

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ABSTRACT

The aim of this research was to evaluate the effect of adding three differing levels of *Opuntia ficus-indica* (OFI) to the diet of Holstein cows in a period of drought and its influence on milk production (MP). Six cows with an average of 56.9 days on milk were subjected to a replicated Latin square design (3 x 3). The cows were assigned to two groups, each group (n=3) was fed with three different diets containing 10, 20 and 30 kg cow^{-1} d^{-1}. The feed was giving in alternating cycles of seven-day cactus pear diet and seven-day rest period, in which, there was not cactus pear supplementation. Fresh cactus pear was cut into pieces (approximately 5 x 5 cm) and given to the cows, within seven days after being harvested. Resultant data were analyzed using the least squares methodology: statistical differences between treatments means were performed by the Tukey test. The group, week (group) and cows (group) did not affect the MP ($P>0.05$); however, treatment did affect the MP ($P=0.0042$). The diet containing 10 and 20 kg d^{-1} of cactus pear improved the MP: 12.182 and 12.716 kg milk d^{-1}, respectively; both being statistically equal ($P>0.05$); however, these means were different ($P<0.05$) when compared to the diet containing 30 kg d^{-1} of cactus pear, which decreased MP (11.026 kg milk cow^{-1} d^{-1}). Therefore, diets containing 10 or 20 kg cow^{-1} d^{-1} were the best choice to maintain herd productivity during the dry season.

Keywords: Cactus pear, dairy cattle, production.

INTRODUCTION

Prolonged drought has forced producers, specifically dairy-cattle farmers, in the rural areas of Mexico, to use local forage, such as cactus pear (*Opuntia* spp.), also called “nopal” in Mexico (Ortiz *et al*. 2012). The nopal, grows abundantly, mainly, in semi-arid and arid areas; there are approximately 61 species of endemic cactus in North America (Gallegos *et al*. 2011). In northern and central Mexico, the cactus fodder occupies 15.8% of the total grazing area, making *Opuntia* spp. as a promising source of supplementary animal feed during the dry season. *O. ficus-indica* has a high content of soluble carbohydrates and calcium; 47% neutral detergent fiber (NDF); 16% acid detergent fiber (ADF), and *in situ* digestibility of 68% at 48 h (Medina *et al*. 2006).

Gonzalez *et al*. (1998) recommend using between 20 and 30% of *Opuntia* spp. as dry matter (DM) to increase milk production (MP) in cattle. Also, it has been found that the use of nopal as a dietary supplement for dairy cows increases MP (López *et al*., 2003). There are reports of increases of 3.7 L cow^{-1} d^{-1}receiving diets supplemented with 12 kg cow^{-1} d^{-1} of *O. ficus-indica*, as fed (basis) (Perez *et al*., 2010; Ortiz *et al*., 2012). However, it has been established that the daily consumption per head could be between 20 to 40 kg of nopal (AF) d^{-1}. This plant provides 4.5% of the total energy required for lactation, 12.2% of protein, 46% of crude fiber, 15% of phosphorus and 100% of calcium (NRC, 2001).

The consumption of *Opuntia* in extreme drought conditions may reach 90 kg AF $head^{-1}$ d^{-1} (López *et al*. 2003). Due to the wide variations in reported consumption of fresh nopal, it is necessary to establish the ideal amount of nopal in cattle diets during drought, relative to optimum MP. Therefore, the aim of the present study was to evaluate the effect of three supplementary amounts (10, 20 and 30 kg) of nopal (AF) in the diet of Holstein cows, during the dry season and its influence on milk production in Uruapan, Michoacan, Mexico.

MATERIALS AND MHETODS

This research was conducted at the Experimental Farm of the Faculty of Agrobiology "Presidente Juarez" affiliated to the Universidad Michoacana de San Nicolas de Hidalgo, located in Uruapan Michoacan, Mexico, between parallels 19° 11’ and 19° 38’ North Latitude; meridians 101° 56’ and 102° 24’ West Longitude; altitude between 700 and 3,300 masl (INEGI, 2009). The region has sub-humid and semi-humid warm temperate climate, which it corresponds to the Cw classification according to García (2004); with temperatures ranging from 18.8 to 23.4 °C and an annual rainfall of 1,622 mm. The dry season in Uruapan region covers the period from November to May. Average annual evaporation is 101 mm, the highest values being notably between March and June (Servicio Metereológico Nacional, 2010).

Two groups were formed, each comprising three Holstein cows, which had already 3 to 5 parturitions and with 56.9 ± 8.5 days on milk. Each group was fed with a diet containing 10, 20 or 30 kg of nopal (FM) cow^{-1} d^{-1}, which corresponded to 1.5, 3.0 and 4.0 kg of DM, respectively. All diets contained corn silage, wheat bran, ground corn, molasses and dairy feed concentrate. The diets were isonitrogenous and isoenergetics. The content of protein

and metabolizable energy in the diets were similar, showing a value range from 1,209 to 1,223 g and 30.4 to 31.5 Mcal, respectively. In Table 1, the composition of the diets is shown.

Table 1. Dietary ingredients of diets for dairy cattle in the dry season according to the amount of nopal (*O. ficus-indica*) supplemented.

Ingredient	Dry matter		As fed
	kg	%	kg
Diet with 10 kg of nopal			
Corn silage	6.00	29	20.70
Wheat bran	1.20	89	1.35
Ground corn	2.00	89	2.25
Molasses	0.90	75	1.20
Opuntia ficus-indica	1.50	15	10.00
Commercial feed for dairy cows	0.80	90	0.89
Total kg d^{-1}	12.40[a]		36.40
Diet with 20 kg of nopal			
Corn silage	4.50	29	15.50
Wheat bran	1.90	89	2.13
Ground corn	0.80	89	0.90
Molasses	0.90	75	1.20
Opuntia ficus-indica	3.00	15	20.00
Commercial feed for dairy cows	1.00	90	1.11
Total kg d^{-1}	12.10[b]		40.90
Diet with 30 kg of nopal			
Corn silage	3.00	29	10.34
Wheat bran	1.90	89	2.13
Ground corn	1.00	89	1.12
Molasses	0.90	75	1.20
Opuntia ficus-indica	4.00	15	30.00
Commercial feed for dairy cows	1.00	90	1.11
Total kg d^{-1}	12.30[c]		45.91

[a] Crude protein (1,215 g); Metabolizable energy (31.5 Mcal); Ca (194 g); P (206 g); Crude fiber (2,264 g)
[b] Crude protein (1,223 g); Metabolizable energy (30.4 Mcal); Ca (260 g); P (251 g); Crude fiber (1,684 g)
[c] Crude protein (1,209 g); Metabolizable energy (31.3 Mcal); Ca (295 g); P (251.6 g); Crude fiber (1,658 g).

Before starting the experiment, there was a period of 7 days of adaptation of animals to a control diet without including *O. ficus-indica*. Each diet was fed for seven days, followed by a seven-day resting period. Wettstein *et al*. (2000), reports that for the adaptation of cattle to a new diet is sufficient a period of three days, and Carmona *et al*. (2005), describes a seven-day period of adaptation is appropriate to include a new diet in cattle. *O. ficus-indica* was harvested from a field in which only weed control was carried out; cladodes came from the

third level of the plants (approximately 1 year old). The chemical composition of cladodes was: 13.39 ± 2.67% dry matter, 31.7 ± 3.55% crude fiber, 4.38 ± 1.07% crude protein and 41.36 ± 2.34% free nitrogen extract. Cladodes were cut into pieces (approximately 5 x 5 cm) and used within 7 days after being harvested. The California test was conducted every seven days on each individual animal to verify the health of the udder during the experimental period. All cows present an optimal health status of the udder.

MP was measured continuously, comprising experimental and resting periods; however, only MP from experimental periods was statistically analyzed. The experimental design was a repeated Latin square (3x3). A database was developed for statistical analysis, using the ANOVA procedure (Herrera and Barreras, 2000). Statistical differences between treatments were obtained using the Tukey test (Herrera and Barreras, 2000). The model used was as follows:

$$Y_{ijkl} = \mu + C_i + H_j(C)_i + Z_k(C)_i + T_l + \varepsilon_{ijkl}$$

Where:
Y_{ijkl} = Milk production
μ = General mean
C_i = Fixed effect of the i^{th} group with $_l = 1, 2$
$H_j(C)_i$ = Effect of j^{th} row (week with $_j = 1, 2$ y 3) within i^{th} group
$Z_k(C)_i$ = Effect of k^{th} column (cow with $_k = 1, 2$ y 3) within del i^{th} group
T_l = Fixed effect of l^{th} treatment with $_l = 10, 20, 30$ kg AF d^{-1}
ε_{ijkl} = Error (NID $\sim$ 0, δ^2)

RESULTS AND DISCUSSION

It was found that the week (group) and cow (group) did not affect the overall average of MP ($P>0.05$), while treatment influenced ($P=0.0042$) the overall average MP (Table 2). Results are in agreement with those reported by Ortiz (2012) and Perez *et al*. (2010), who found no effect from treatments: 0 *vs.* 12 kg head^{-1} d^{-1} of nopal (AF) in the average MP.

Table 2. Analysis of variance for milk production (kg d^{-1}) in cows fed with diets supplemented with nopal (*Opuntia ficus-indica*).

Source of variation	DF	Square means	Pr > F
Group	1	0.15295715	0.4939
Week (Group)	4	0.46433292	0.2865
Cow (Group)	4	1.02518788	0.0813
Treatment	2	4.48403983	0.0042
General Mean		11.976	
Standard deviation		0.537	
R^2		0.89	

The effect of treatment on MP showed how the inclusion of 10 or 20 kg of nopal (AF) cow^{-1} d^{-1} improved yield: 12.185 ± 0.306 and 12.716 ± 0.515 kg of milk d^{-1}; both means were similar

(P>0.05), but different (P<0.05) to the diet containing 30 kg of nopal cow^{-1} d^{-1} (11.026 ± 1.099 kg of milk d^{-1}) (Fig. 1). MP from cows fed without nopal, had a value of 10.152 kg of milk cow^{-1} d^{-1}. In all cases, when nopal was added to the diets, the MP value was higher as compared to the control.

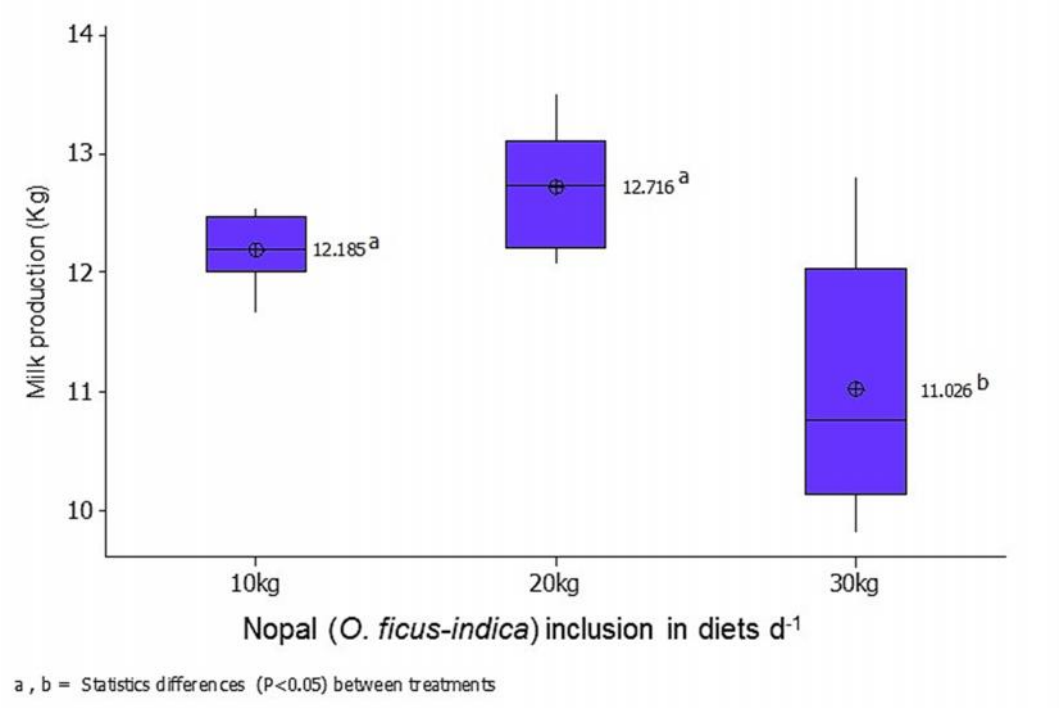

Figure 1. Milk production cow^{-1} d^{-1} according to the supplementation of nopal (*O. ficus-indica*) in the diet of Holstein cows during the dry season.

The difference in MP resulting from the varied supplementary amounts of nopal in the diet (10, 20 or 30 kg cow^{-1} d^{-1}, AF) (Figure 1), was consistent with the values reported by Gonzalez *et al*. (1988), which found that milk production decreased by 3.2 kg^{-1} day^{-1} in cattle fed diets containing 30 kg (AF) of nopal compared without nopal diet.

Dos Santos *et al*. (1998) obtained a MP average of 12.73 kg cow^{-1} d^{-1} when the amount of nopal (AF) in the diet was 59.22 kg^{-1} cow^{-1} day^{-1}. Magalhães *et al*. (2004) obtained a MP average of 11.71 cow^{-1} d^{-1} when the amount of nopal (AF) in the diet was 44.36 kg d^{-1}, while Perez *et al*. (2010), found MP of 10.86 L cow^{-1} d^{-1} with diets supplemented with 12 kg of nopal (AF) cow^{-1} d^{-1}, in contrast to control diets (without nopal added) of 7.08 L cow^{-1} d^{-1}.

Milk production increased 0.531 kg when cactus consumption was 20 kg d^{-1}, compared when nopal consumption was only 10 kg d^{-1}. In addition, a decrease in milk production in 1,159 kg was observed when nopal consumption was 30 kg^{-1} cow^{-1} day^{-1}, compared when nopal consumption was 10 kg d^{-1}. These results demonstrate that the inclusion of nopal in the diet of dairy cattle increases MP only if the amount is less than 30 kg d^{-1} of nopal. This effect of decreased MP, in diets supplemented with 30 kg d^{-1} nopal, may be related to the decrease in

the apparent digestibility of DM together with organic matter in response to increased amount of dietary nopal (Bezerra *et al*., 2002). Increased nopal concentration in the diet produces a negative relationship between NDF and non-structural carbohydrates (NSC): low NDF content present in nopal *vs.* high NSC content cause a decrease in ruminal pH, due to less salivation (Mertens, 2001; Bezerra *et al.*, 2002; Romero *et al.*, 2005; Almaraz *et al*., 2012); another possibility is, that by increasing the content of dietary nopal, microbial fermentation decreases and consequently, digestion also diminishes (Veras *et al*., 2000.), producing a negative impact on the balance of nutrients for milk synthesis, which would suggest that diets containing nopal, more than 20 kg cow^{-1} d^{-1}.

A maximum supplementary amount of nopal (AF) of 20 kg d^{-1} in the diet of dairy cattle in rural areas, during prolonged drought, may improve productivity. Nopal provides soluble sugars which combine with other dietary nutrients may enhance ruminal fermentation and increase ratio of volatile fatty acids (acetic, propionic and butyric acid) for the synthesis of milk as mentioned by Torres (2010).

CONCLUSION

The addition of 10 or 20 kg of nopal (AF) cow^{-1} d^{-1} in the diet increases milk production in Holstein cows – as opposed to supplementing 30 kg d^{-1}, which actively decreases it. Supplementing in a range from 10 to 20 kg of nopal (AF) cow^{-1} d^{-1} in diets for Holstein cows in rural areas is an excellent option.

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