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Effect of Forage Level in Diets for Lactating Holstein Cows

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Abstract: A total of 12 Holstein dairy cows were used to evaluate the effects of treatments on dairy production and milk quality. Treatments were according to the ratio forage concentrate on diet: T1) 70:30; T2) 65:35; T3) 60:30; T4) 55:45. Twenty kilogram of total diet was offered daily, 10 kg at 07:00 and 15:00 h. The period length of the experiment was 51 day, considering the first 21 day for adaptation. Treatment 1 decreased milk yield and increased fat levels according with weekly measurements. Not effects of treatments on protein, lactose, or non-fat solids levels were observed. Considering with the hold experiment, milk yield level was according with the levels observed during each of 4 weeks; decreasing when alfalfa level increased. Fat milk level was according with the tendency observed weekly, increasing when alfalfa level increased. The levels of protein increased when the amount of concentrate increased. The findings of this experiment suggest that 60% of alfalfa mixed with 40% concentrate offered as total diet in Holstein dairy cows could be a good way to increase yield milk and to improve its quality.

Key words: Holstein, milk production, milk quality, forage, concentrate

INTRODUCTION

The traditional method used in the feeding of producing cows in dairies of the most places in Mexico is based in high levels of forage, mainly alfalfa, besides the complementation of commercial concentrates offered according with milk production. With these diets it is expected to fulfill the nutrient requirements of the producing cows, avoid digestive problems related to the intake of high levels of the energetic components, mainly laminitis, acidosis and consequences in the feed intake (Grant, 1998; Miller, 1998).

To increase milk production and its nutrimental quality, different feeding alternatives are suggested, as the addition of intermediary metabolites (Vandehaar *et al*., 1988) and the inclusion of energetic components (Middaugh *et al*., 1988; Oldick and Firkins, 2000).

At present, there is a controversy in fixing limits of inclusion of both ingredients to obtain high milk production without affecting the productive efficiency and health of the animals. Some recommend the high-energy inclusion as concentrate feeds in total diet (Keser and Spahr, 1964) it could produce a decrease in ruminal pH (Heinrichs *et al*., 1999) with a decrease in rumen-digestion of fiber (Hoover, 1986) the inclusion of high forage levels which prevent the digestive-metabolic problems incidence as response to the complex interactions across forage and microorganisms of the digestive tract (Mertens and Ely, 1982), they are a natural energy source for microbial development in rumen (Smith *et al*., 1983), they can produce a decrees in ruminal digestibility with their diet increase (Weiss, 1993; Bargo *et al*., 2002) it is in agreement with Voelker *et al*. (2002), who say that it is a result a physic-chemist mechanisms.

By the last, it is suggested the necessity of fixing clear ranges for both feed types, as concentrates as forages, for lactating Holstein cows. In other hand, it is well documented that some factors affect milk composition, between the most important are: genetics, state of milk production, age, environment, nutrition and health status. In milk composition variation, 55% is because heredability and 45% to environmental factors, mainly feeding. In basis to the last, the objective of this study was to determinate the optimal forage: concentrate rate in lactating cows diets.

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MATERIALS AND METHODS

Location area: The study was carried out in Mexicali, B.C., Mexico. The weather is hot and dry, with an average mean temperature of 22°C with oscillations higher to 14°C and with winter rainfall.

Experimental procedure: A total of 12 Holstein cows of 570 kg of average body weight were used in this experiment, they were in the second third of lactation, with an average of 160 Milk Days (MD). The animals were between 2 and 4 lactation. For milk performance trial, 4 blocks of 3 cows each one was used. The cows were housed in 9 m^2 individual pens. The feeder was individual and there was one automatic drinker for each 2 pens. The forage: concentrate ratio of the treatments (T) was: T1) 70:30; T2) 65:35; T3) 60:40; T4) 55:45 (Table 1). The offered dry matter was 3.5% of the animal body weight; the daily feed consisted of 20 kg as total diet, which was offered in 2 equal parts (10 kg each one) at 0700 and 1700 h. The diet was formulated according with NRC (1988).

The trial lasted 51 day, of which 21 day were the adaptation period and 30 day of sample collection. There two milkings per day (0400 and 1600 h) using a milking machine. The record of milk production was taken after each milking, taking 2 daily records in 2 different days per week (Jensen *et al*., 1962), using an electronic balance. Each sample consisted of 100 mL of milk approximately and they were deposited in hermetic nylon bags (Nasco Whirl-Pak. Fisher® 4 oz.) and kept at -20°C for further laboratory analysis. To be sure about diet quality along the experimental period, samples of compete diet (2 kg each) were obtained during the collection period for chemical analysis. The feed samples were dried at 55°C during 72 h, after that, they were processed at Willey Mill (Lab. Mill Mod. 4 Thomas Willey. Arthur Thomas, USA) in a 2 mm diameter mash; after that, samples were grinded with a laboratory mill (Micro-Mill, Bel-Arts Products, Pequannock, N.J) and dried at 105°C during 24 h in a air forced stove. (VWR®, Scientific Inc. 1350-G) and kept hermetic glass containers.

Analysis of milk samples: The milk samples were analyzed for fat content (Marshall, 1992) crude protein (AOAC, 1990), total solid by difference in weight at 100°C during 24 h in air forced stove (VWR®, Scientific Inc. 1350-G), ureic-nitrogen (McCullough, 1967) lactose and non-fat solids (AOAC, 1984).

Table 1: Composition of the experimental diets

Treatment	% DM	% CP	EE	%ADF	%NDF	% Ash
70:30	98.97	15.29	2.51	28.49	37.34	8.32
65:35	95.71	15.12	2.72	26.33	34.48	7.75
60:40	98.27	15.47	2.70	23.81	33.13	7.80
55:45	96.44	15.15	2.85	24.49	33.57	7.55

Statistical analysis: Data were analyzed in the statistical package SAS (1996) in a random complete block design (Hicks, 1973).

RESULTS AND DISCUSSION

The treatment effects on variables are shown in period by week (Table 2-5). In the 1st week of collection (Table 2), the lower milk production was in cows of T1, without difference (p>0.10) between treatments 2, 3 and 4. In contrast to this, the higher fat content was in T1 (p<0.05), with a diminution in milk fat content as the forage level in diets decreased; although the lower fat content was in T2, however there were differences in T2 and T4, they were low, 1.53 and 0.55%, respectively. Only the animals in T1 had a milk fat content adequate (3.68%), which is in agreement with Grant (1998) who reported 3.7% of milk fat in Holstein cows. There was not treatment effect (p>0.10) on the levels of protein, lactose and Non Fat Solids (NFS). The levels of Ureic Nitrogen in Milk (UNM) did not affect because the high variation coefficient.

The treatment effects on milk production, % of fat, % protein, lactose, NFS and UNM, for the 2nd week, are shown in Table 3. The lower forage level in diets produced the lower (p<0.05) milk production, with intermediate values for T2 and the higher (p<0.05) production was for T3 and T4, without difference (p>0.10) between both. The fat content was higher (p<0.05) in diet with the higher alfalfa content, without difference (p>0.10) between treatments 2-4. The treatment effects for protein, lactose, NFS and UNM were the same observed during the 1st week.

The treatment effects on milk production, % of fat, % protein, lactose, NFS and UNM, for the 3rd week, are shown in Table 4. There were similar treatment responses to that observed in the last two weeks. Reduction (p<0.05) in milk production was observed in diet with 70% of alfalfa, while T3 had the showed an increase in milk production. Again, the higher (p<0.05) fat in milk was for the diet with 70% of alfalfa, while T2 and T4 had the lower percentages of fat in milk, the T3 showed an intermediate level (p<0.05). There were not differences (p>0.10) across treatments for lactose, NFS and UNM.

Table 2: Effect of forage level on milk production and content of fat, protein, lactose, NFS and UNM. Week 1

Item	Treatments 1	2	3	4	VC
Milk, kg d^{-1}	10.50^a	11.97^b	12.19^b	12.47^b	2.60
Fat, %	3.68^a	2.34^b	3.51^a	3.03^c	3.76
Protein, %	3.06	2.82	3.25	3.23	7.86
Lactose, %	3.66	4.53	4.62	4.94	5.70
NFS, %	8.40	8.01	8.61	8.92	4.92
UNM, mg dL^{-1}	17.42	19.73	10.47	8.89	27.65

^{abc} Different literals in the same row differ (p<0.05), NFS = Non fat solids, UNM = Ureic nitrogen in milk

Table 3: Effect of forage level on milk production and content of fat, protein, lactose, NFS and UNM. Week 2

Item	Treatments 1	2	3	4	VC
Milk, kg d^{-1}	9.11^a	11.23^b	12.74^c	12.34^c	2.35
Fat, %	3.68^a	2.77^b	3.13^b	3.02^b	6.18
Protein, %	3.14	2.63	3.45	3.30	7.30
Lactose, %	4.56	4.48	4.52	4.90	6.45
NFS, %	8.27	7.96	8.58	8.89	5.50
UNM, mg dL^{-1}	18.29	20.38	11.28	11.03	36.39

^{abc} Different literals in the same row differ (p<0.05), NFS = Non fat solids, UNM = Ureic nitrogen in milk

Table 4: Effect of forage level on milk production and content of fat, protein, lactose, NFS and UNM. Week 3

Item	Treatments 1	2	3	4	VC
Milk, kg d^{-1}	10.20^a	11.38^b	12.09^c	11.85^{bc}	2.54
Fat, %	3.78^a	2.99^{bc}	3.18^b	2.77^c	5.14
Protein, %	3.13	2.96	3.44	3.27	6.88
Lactose, %	4.52	4.35	3.50	4.94	6.06
NFS, %	8.18	7.83	8.57	8.91	5.65
UNM, mg dL^{-1}	17.65	17.00	11.54	11.04	40.89

^{abc} Different literals in the same row differ (p<0.05), NFS = Non fat solids, UNM = Ureic nitrogen in milk

Table 5: Effect of forage level on milk production and content of fat, protein, lactose, NFS and UNM. Week 4

Item	Treatments 1	2	3	4	VC
Milk, kg d^{-1}	9.26^a	10.75^b	11.44^b	12.17^c	3.49
Fat, %	3.59^b	2.82^b	3.17^c	2.89^{bc}	5.78
Protein, %	2.90	3.03	3.45	3.27	5.40
Lactose, %	4.63	4.48	4.58	4.94	5.87
NFS, %	8.36	8.00	8.66	8.92	4.91
UNM, mg dL^{-1}	17.52	18.33	8.87	13.50	42.26

^{abc}Different literals in the same row differ (p<0.05), NFS = Non fat solids, UNM = Ureic nitrogen in milk

The treatment effects in week 4 are shown in Table 5. The higher level of alfalfa in the diet reduced the milk production and the higher concentrate levels increased the milk yield, with intermediate levels in T2 and T3 (p<0.05). The fat concentration in milk was constant as in the last weeks (3.59%) in T1 (p<0.05), although there was a low response in T2 and T4, while T3 had an acceptable fat content in milk (3.17%; p<0.05). No difference (p>0.10) was observed between treatments for lactose, NFS and UNM.

The treatment effects in all trial are shown in Table 6. The milk production had a lineal trend in the 4 weeks, which was lower in the lower concentrate level in the total diet (p<0.05). This way, increasing the concentrate in diets, 30, 35, 40 and 45%, respectively, increased the milk production (p<0.05). This is in agreement with Nichols *et al.* (1988) where, as the forage level in diets was increased, there was a lineal reduction in feed intake and milk production. The fat content in milk had a constant trend across all the experiment, it had an increment with

Table 6: Effect of forage level on milk production and content of fat, protein, lactose, NFS and UNM for complete experiment

	Treatments				
Item	1	2	3	4	VC
Milk, kg d^{-1}	9.77[a]	11.42[b]	12.12[c]	12.12[c]	4.65
Fat, %	3.68[a]	2.73[b]	3.25[c]	2.92[d]	6.87
Protein, %	3.06[a]	2.86[b]	3.40[c]	3.27[c]	6.76
Lactose, %	4.59[a]	4.45[a]	4.56[a]	4.93[b]	5.26
NFS, %	8.30[a]	7.95[b]	8.60[ac]	8.91[c]	4.53
UNM, mg dL^{-1}	20.22	18.86	11.12	11.36	42.53

[abc] Different literals in the same row differ (p<0.05), NFS = Non fat solids, UNM = Ureic nitrogen in milk

the inclusion of high quantities of alfalfa in diets. This is in agreement with Beitz and Davis (1964) and Weiss and Shockey (1991), who used different forage level in diets and are in agreement with West *et al*. (1987), this could be due because there was not an adequate ruminal acetate: propionate ratio.

Sutton and Morant (1989) did not observe forage level effect on protein content in milk. In the present trial, the percentage of protein decreased ($p<0.05$) in response to the higher levels of alfalfa supplementation. While, levels of 55 and 60% of alfalfa had 3.4 and 3.27% of fat in milk, which are in agreement with the 3.1% suggested by Grant (1998), the values are very acceptable.

The lactose concentration observed an increment in T4 (4.93%; $p<0.05$), without differences ($p>0.10$) between the others treatments. Grant (1998) found a lactose average in milk of Holstein cow of 4.6 to 4.8%, which is in agreement with the present trial. In addition, there was a small increment in the value of NFS ($p<0.05$), with the lower levels for T2 (7.95%; $p>0.10$).

The last exposition suggest that the inclusion of 60% of alfalfa mixed with 40% of concentrate in total diet of lactating Holstein cows offers a good alternative when the objective in dairy cattle feeding is to maintain a right balance between milk production and its components.

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