EFFECT OF MAGNESIUM OXIDE (Mgo) ADDITION IN DIETS FOR LACTATING HOLSTEIN COWS

Efecto de la Adición de Óxido de Magnesio (MgO) en Dietas para Vacas Holstein en Lactación

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ABSTRACT

It was evaluated the effect of magnesium oxide (MgO) addition in diets for Holstein cows on milk production and quality. Nineteen Holstein cows in second third of lactation were assigned to two treatments (T), with 9 and 10 animals. Both treatments were similar for days in lactation and milk yield. Cows were assigned at random to two treatments (T) groups: T1 received 0.2% and T2 received 0.4% of MgO. The MgO (alkalinizing agent) was mixed with a commercial concentrate and offered in feed bunk with total diet, which consisted of 9 kg/d of concentrate plus alfalfa hay fed *ad libitum*. Total diet was offered three times a day (0600; 1200 and 1700 h). The experimental period was of 30 d, with other 30 for adaptation. Milk production (kg/d) and milk quality (fat, protein, and total solids) were evaluated. Data were analyzed using the statistical package SAS through of a randomized block design. Animals on T2 (0.40% MgO) produced 2.85 kg/d more milk ($P<0.50$) than those on T1 (0.20% MgO). The fat, protein and total solids content in milk were higher ($P<0.05$) in T1 than in T2. It is concluded that the addition of 0.4% MgO in diets for lactating dairy cows resulted in milk production increased, although there was a small reduction in milk quality, compared with 0.2% MgO supplementation.

Key words: Magnesium oxide, buffer, Holstein cows, milk.

RESUMEN

Se evaluó el efecto de adición de óxido de magnesio (MgO) en dietas para vacas Holstein sobre la producción y calidad de la leche. Diecinueve vacas Holstein en el segundo tercio de lactancia fueron asignadas a dos tratamientos (T), con 9 y 10 animales. Ambos tratamientos fueron similares para días de lactancia y producción de leche. Las vacas fueron asignadas al azar a dos grupos o tratamientos (T): T1 recibió 0,2%, y T2 recibió 0,4% de MgO. El MgO (agente alcalinizante) se mezcló con un concentrado comercial y se ofreció en el comedero junto con la dieta total, la cual consistió de 9 kg/d del concentrado mas heno de alfalfa *ad libitum*. La dieta total se ofreció 3 veces al día (06000, 1200 and 1700 h). El periodo experimental fue de 30 d, con otros 30 d de adaptación. Se evaluó la producción de leche (kg/d) y la calidad de la leche (grasa, proteína, y sólidos totales). Los datos se analizaron por medio del paquete estadístico SAS en un diseño de bloques al azar. Los animales en T2 (0,4% MgO) produjeron más leche (2,5 kg/d; $P<0,05$) que aquellos en T1 (0,20% MgO). El contenido de grasa, proteína, y sólidos totales en leche fue más alto ($P<0,05$) en T1 que en T2. Se concluye que la adición de 0,40% de MgO en dietas para vacas lactantes incrementa la producción de leche, sin embargo puede haber una pequeña reducción en la calidad de la leche, comparado con la suplementación de 0,20% de MgO.

Palabras clave: Óxido de magnesio, buffer, vacas Holstein, leche.

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INTRODUCTION

Usually dairy farms from Norwest of Mexico during lactation base their feeding programs in forages, mainly in good-quality alfalfa (*Medicago sativa*) hay. Forages stimulate ruminal activity, which promotes adequate saliva production that functions as a natural buffer. Forages are known as the most cost-effective feed sources [4], and because of that, they are used in high amounts in dairy farms, together with concentrates supplementation. The increase in milk yield, in addition to the feed efficiency in dairy cows (*Bos taurus*), allows the use of high amounts of concentrates or high energy rations. To maintain high milk yield require high energy intake, which is provided by high concentrate levels, which can be offered at milking time or directly at feed bunk [23].

Under these feeding conditions, the propionic acid is increased and the acetic acid is reduced [5, 13]. It is pointed out that these changes in ruminal fermentation cause a ruminal pH reduction and a metabolic disorder may occur [10]. The buffer addition to rations increase acetate and reduce propionate, increasing the acetate:propionate ratio [15, 18].

The milk industry is seeking for a high-performance in milk production in addition to a high-quality product; within milk fat concentration is of big importance. Nevertheless, to obtain a satisfactory amount, it is necessary to provide to the animal large amounts of grain or high-energy rations, which cause a diminution in milk fat content [12]. There is a positive linear relation between acetate:propionate ratio and the percentage of milk fat [39]. In order to reach this last goal, in practice it is recommended minimal acid detergent fiber (ADF) content in ration (19%) [26], as well as the buffers addition [6, 9, 38, 40]. The effect of diet on protein in milk is not well established [19]. The objective of present experiment was to determine the effect of MgO addition in diets for Holstein cows on production and quality of milk.

MATERIALS & METHODS

Location

The experiment was performed at the dairy farm of the Instituto de Investigaciones en Ciencias Veterinarias-UABC, located in Mexicali, B.C., México. Mean temperature and relative humidity (RH) registered during the experimental period were 18.53°C and 40.20%, respectively. Temperature oscillated from 7.9 to 33.5°C and RH from 10.3 to 98.9% [30].

Experimental procedures

Nineteen Holstein cows in second third of lactation were used. Cows were assigned to two treatments (T) diets with 9 and 10 animals, for T1 and T2, respectively. The cows in both treatments were similar in milk production and lactation days. Animals were assigned at random to one of the two blocks in basis to milk production records. Blocks were used to have cows in both treatments similar in milk production. Cows were assigned at random to two treatments (T) groups: T1 received 0.2% and T2, received 0.4% of MgO (MAGOX®. Premier Chemicals, USA). The MgO (alkalinizing agent) was mixed with a commercial concentrate (MAXI-TECH 16. Purina, S.A. de C.V.), and then it was offered in feed bunk with total diet, which consisted of 9 kg/d of concentrate plus alfalfa hay fed *ad libitum*. Total diet was offered three times day (0600; 1200 and 1700 h). The experimental period was of 30 d. Milk yield (kg/d) was recorded twice a week, according to the procedures of Jensen [21] and using a Waikato equipment (Waikato Milkmeter. Model: 8301331-83 with 65 lb/30 kg flask. Agricultural Division. Terez, New Zeland). Records were taken during the milking in morning (0500 h) and afternoon (1700 h). Simultaneously, milk samples were taken for determination of fat, protein, and total solids, collecting approximately 100 mL of milk per sample and deposited in nylon bags for further analyses (*Nasco* WHIRL-PAK. FISHER of 4 oz, USA).

Sample analysis

Samples were analyzed for fat according to the methodology of Babcock [2; AOAC official method 989.04], using a Garver centrifuge (Garver Electrifuge for testing milk and cream. Babcock Method. Mod. 55. Garver Manufact. Co, USA). Butirometers of 8 and 10% and a Garver Shaker (Garver Shaker. Mod. 240. Garver Manufact. Co, USA).

Crude protein was determined by the method of the AOAC [2; AOAC official method 991.20], using a Kjeldahl equipment (Tecator 2020 Digestor, Tecator Kjeltec System 1026 Distilling Unit, USA). Total solids in milk were determined by difference, depositing 3 mL of milk in aluminum caps (3 cm in diameter and 0.5 cm in height) and they were weighed and placed into air forced oven at 100°C (VWR, Scientific Inc. 1350-G, USA) for 24 h, and after that time the aluminum caps were weighed again.

Statistics

Data were analyzed using the statistical package SAS [32] through a randomized block design ($P<0.05$), the variance analyses considered treatment, block and the interaction treatment x block, according with the procedures of Steel and Torrie [33], with the probabilistic model:

$$Y_{ij} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \varepsilon_{ijk}$$

where:

Y_{ij} = Variable of response

μ = General mean

τ_i = Effect of treatment, i =1...t=2

β_j = Effect of block, j =1...b=2

$(\tau\beta)$ = Interaction, k=1.....n$\neq i$

ε_{ijk} = Experimental error

RESULTS AND DISCUSION

Treatments effects on yield and quality of milk by the dairy cows receiving the different levels of MgO in diets are shown in TABLE I. In average for the four weeks evaluation, animals on T2 (0.40% MgO) produced 2.85 kg/d more milk (P<0.50) than those on T1 (0.20% MgO). Rich concentrate diets for ruminants contain high amounts of starch which is a readily fermentable carbohydrate. When high starch rations are fed, amylolitic organisms are found in larger percentages of the total microbial population, because rapid fermentation decrease rumen pH which encourages amylolytic microorganisms to proliferate [28] and celluloliyic bacteria decrease because of low pH in rumen [34]. The low pH may cause acidosis, which is a metabolic disorder that can be the result of excess feeding of nonfibrous carbohydrates (NFC), a rapid increase in the dietary content of NFC, or insufficient rumen buffering [27]. Consistently, low pH in rumen pH reduced fiber digestion [7, 8, 25]. In the present research, higher MgO level in diet could increase ruminal pH though improvement in buffer capacity, which may enhance the cellulolytic bacteria and resulting in greater fiber digestion; also ruminal volatile free acids (VFA) pattern could be changed, increasing the acetate production, and reflected in greater acetate: propionate ratio. In agreement with present research has been observed that acetate to propionate ratio increased with addition of sodium bicarbonate (NaHCO3) and MgO in combination [36]. Although, others [1, 11, 29] reported that, molar proportions of VFA were unaffected by buffer addition.

For the present research, fat content in milk was higher in T2, which is consistent with the increment in the acetate to propionate ratio. This sense has been observed that milk fat percent tended to increase with buffers addition in diet, although there was no effect on total VFA concentration or profile [35]. Several factors are responsible of these differences among reports, one of them is the forage:concentrate ratio; this case, buffer addition to high forage diets may not influence rumen fermentation, while high concentrate diets may have greater influence. In addition to forage:concentrate ratio, also ingredient composition of concentrate may have effect on rumen fermentation. Significant responses to buffers supplementation on rumen fermentation were not observed, in part due to the high fiber content of total ration, due to inclusion in diet of whole cottonseed and wheat bran plus alfalfa hay which are fiber rich [1]. Therefore, in the present research, the concentrate was mainly formed by cereal grains and oil seed cakes which are easily rumen-fermented, and this partially explain the positive response in milk fat content to the higher MgO addition in diet.

It is observed in FIG. 1 that during the fourth weeks the animals on T2 had higher milk yield that those fed on T1. Milk production through the experiment showed less variation in animals on T2 than those on T1, especially for the third week where animals on T1 reduced and those on T2 increased milk yield. These results are in agreement with researchers [36] whom reported higher (P<0.05) milk yield for animals receiving 0.40% MgO than those on control group and those receiving 0.80% MgO (38.3 *vs.* 35.2 and 34.8 kg/d, respectively). Similarly, it was found that cows receiving 0.80% MgO increased in 0.6 kg/d milk yield than those in control group, although no statistical effect [18]. Others buffers in diet increased dry matter and water intake, milk yield, milk fat early lactating buffaloes [31]. In contrast, other research [17] did not find effect on milk yield with the addition of 0.80% MgO. Similar results reported

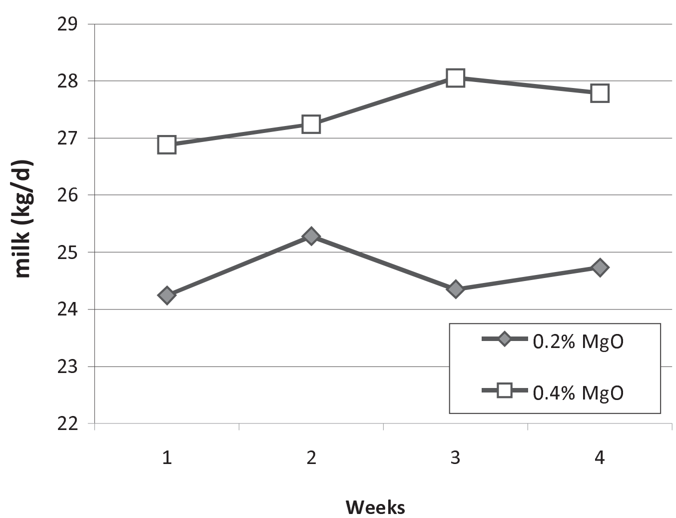

FIGURE I. MILK PRODUCTION BY COWS DURING THE EXPERIMENT / PRODUCCIÓN DE LECHE DURANTE EL EXPERIMENTO.

TABLE I

AVERAGE OF MILK YIELD AND QUALITY OF DAIRY COWS RECEIVING DIFFERENT MgO LEVELS IN DIET / PROMEDIO DE PRODUCCION Y CALIDAD DE LA LECHE DE VACAS RECIBIENDO DIFERENTES NIVELES DE MgO EN LA DIETA

Item	Treatments		SEM
	0.2% MgO	0.4% MgO	
Milk yield (kg/d)	24.65^{b}	27.50^{a}	3.02
Fat in milk (%)	2.45^{a}	2.74^{b}	0.33
Protein (%)	3.29^{a}	3.19^{b}	0.08
Total solids (%)	11.72^{a}	11.43^{b}	1.28

^{a,b} Different superscript in same row differ (P<0.05).

[14, 22, 37] a reduction in milk yield by the MgO, or other buffer ($NaHCO_3$) supplementation, these effect may be attributed to the feed intake reduction in treated animals. In this regard, in a review is reported that when forage level was up to 30% of the ration, there was no effect on milk production (29.6 *vs.* 29.7 kg), nevertheless with less of 30% of forage in ration caused a reduction in milk yield (17.2 *vs.* 16.1 kg) [19].

In milk production response to buffer addition in diets among the different reports may be due to the different conditions where the experiments were conducted. Factors that may act on milk yield and its composition may be buffer level, forage type and dry matter intake. In this regard, researchers [20] using a mixed model of statistical analysis, examined the effects of dietary $NaHCO_3$ on performance of early- and mid-lactation dairy cows. The statistical model included the fixed effects of buffer concentration and forage type, and the random effect of study. They found better dry matter intake in cows in $NaHCO_3$ and fed maize silage than different forage source. Milk production, milk protein percentage, and protein yield were unaffected by buffer treatments regardless of forage type, but milk fat concentration of cows fed maize silage based diets was 2.7 g/kg higher ($P < 0.02$) when $NaHCO_3$ was included. They concluded that differences in response to buffer treatments between forage types might partially be due to variation in the fiber contents of the forage.

In the present study, the milk fat concentration was higher (0.29%; $P<0.05$) in T2 (0.4% MgO) than in T1 (0.2% MgO). In agreement, similar results found that the 0.80% MgO addition in diets for Holstein and Jersey cows reduced milk fat concentration in 0.18% in comparison with control group [17]. However, most research shows no change or small increase in milk fat content by MgO or other buffer addition to dairy cows rations. In this regard a research compared different levels (0, 0.4 and 0.8%) of MgO in dairy cows; they did not find effect of treatments on milk fat percentage ($P>0.05$), although no differences, there was numerical tendency to increase with higher MgO levels (3.60, 3.63 and 3.71%, respectively) [36]. It was observed tendency to increase ($P<0.20$) in 0.49% milk fat for MgO supplemented lactating dairy cows, compared with control group [37]. Similar results were observed on milk fat concentration using NaHCO3 or MgO, compared with control group [16]. Comparable responses were obtained in others experiments [18]. Further experiments [16, 22] also showed higher ($P<0.05$) milk fat percentage with MgO supplementation in lactating cows, compared with ration without MgO.

In this experiment, animals on T1 (0.2% MgO) had higher ($P<0.05$) protein content in milk than those supplemented with 0.4% MgO (T2). In agreement with present experiment [19] reported that the protein content in milk was reduced with the MgO treatment, compared with animals without treatment (3.13 *vs.* 3.07%). According with the present observed results [38] that milk protein content were greatest ($P<0.005$) for cows fed control. They have no explanation why milk protein percent was greater for control cows, since most studies found little or no effect of NaHCO3 or MgO on milk protein concentration [24, 37].

Total solids percentage in milk was higher ($P<0.05$) for animals receiving 0.20% than those receiving 0.40% MgO in diet. In agreement, it was found that MgO addition in diets for lactating Holstein cows tended to reduce total solid in milk, compared to control group or those receiving $NaHCO_3$ (9 *vs.* 9.58 or 9.2%, respectively) [14]. No effect of $NaHCO_3$ or MgO inclusion was observed on milk production or composition in a ration with high forage level for dairy cows [1]. On the other hand, it was found increases total solids (TS) percentages in milk after buffer addition [3]. In addition, increases in TS have been more marked with both, NaHCO3 and MgO, than with either alone [37]. For the present research, the diminution in total solids could be caused by the protein reduction in milk, since the increase in fat content did not reflected in total solids in milk.

CONCLUSION

The results of the present research indicate that the addition of 0.4% MgO to a diet containing concentrate plus alfalfa hay for lactating cows may increase milk fat and yield, although may be a small reduction in protein and total solids in milk, compared with 0.2% MgO supplementation.

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