Effects of Bentonite Supplementation on Milk Yield, Milk Composition, Digestibility and Nutritive Values in Holstein Cows

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Abstract: The objective of this study was to determine effects of inclusion Bentonite in lactating dairy cows rations on milk yield, milk composition as well as digestibility, nutritive values and blood urea, alkaline phosphatase, total protein, and liver enzymes. 72 Holstein Frisian cows weighed 650 ± 5 kg were randomly divided into 3 groups (24 cows in each group) fed 3 rations as follows: ration 1 (control) without additives, ration 2 supplemented with 70 g Bentonite/cow/day, and ration 3 supplemented with 120 g Bentonite/cow/day. Experiment lasted for two months. Cows fed on TMR (Total Mixed Ration) which consisted of concentrate feed mixture, corn silage and clover hay. Milk production was recorded. Milk samples were taken, fat, protein and lactose percentages were estimated. Fresh feces samples were collected for five days and dried in oven at 65°C for 24 hrs, then mixed and then representative samples were taken for chemical analysis. Bentonite added as 70g Bentonite/cow/day significantly ($P < 0.05$) increased Organic Matter (OM), Crude Protein (CP), Crude Fiber (CF) and Nitrogen Free Extract (NFE) digestibility. Bentonite added as 120g/cow/day decreased (OM) digestibility. Milk yield, Fat Corrected Milk (FCM), fat, protein and lactose of lactating cows was increased by adding Bentonite as 70 g/cow/day. All values of blood urea, Alkaline phosphatase, AST and ALT enzymes in all groups in this study lied within the normal levels.

Keywords: Bentonite, Clay Minerals, Milk Yield, Milk Composition, digestibility

INTRODUCTION

Natural clays such as Bentonite are crystalline aluminosilicates characterized by their ability to exchange cations without major changes in structure. Clay particles have negative charges along the edges. The negative charges of clays attract positively charged ions or cations such as ammonium (NH_4^+) and sodium (Na^+). This property suggested that nature clays as Bentonite could be a beneficial feed ingredient. Clay minerals improved feed conversion and adsorption of mycotoxins and improved production and health of livestock (Nadziakiewicz *et al.*, 2019). El-Saadany *et al.* (2003) mentioned that chemical composition of Bentonite clay was 53.05% SiO_2 , 20.26% Al_2O_3 , 6.74% Fe_2O_3 , 4.64% MgO , 1.95% CaO , 2.19% Na_2O and 1.05% K_2O . Ibrahim (2012) mentioned that chemical composition of tafla was SiO_2 50.05%, Al_2O_3 20.26%, Fe_2O_3 4.74%, CaO 2.02%, MgO 1.95%, Na_2O 2.19% and K_2O 1.05%. Pasha *et al.*, (2007) explained that Bentonite binds aflatoxins present in the feed and consequently prevent aflatoxin toxicity in farm animals. Rindsig *et al.* (1969) reported that milk production was higher in lactating cows fed high concentrate ration with Bentonite and low level of Bentonite was best than high level. Bentonite clay was used far in history as a traditional healing method for protecting the body from diseases. Because this clay is readily available, it has been a popular and cost-effective way of detoxing the body for quite some time. People have eaten Bentonite clay or put it on their skin for thousands of years. It has been used to clean or protect skin, heal skin infections, treat stomach gas and ease diarrhea. Pasha *et al.* (2007) explained that Bentonite is a hydrated aluminum silicate of volcanic origin which contained 50-90% from mineral montmorillonite. Bentonite has a high cation exchange capacity such as Na^+ , K^+ , Ca^{++} , and Mg^{++} (Its cation exchange capacity is 80-120 meq/100g).

The objective of this work was to study the effect of adding Bentonite in the total mixed rations (TMR) on performance of high yielding lactating cows.

MATERIALS AND METHODS

Experiments were conducted at milk station 2, El-Salhia Farm and Laboratories of Animal Production Department at Faculty of Agriculture, Suez Canal University (Ismailia Governorate), Egypt. 72 Holstein Frisian cows weighed 650 ± 5 kg were randomly divided into 3 groups (24 cows in each group), fed 3 rations as follows: ration 1 (control) without additives, ration 2 adding 80g Bentonite /cow/day, and ration 3 adding 140g Bentonite /cow/day. The feed requirements were calculated according to NRC, (2001). TMR was daily offered to animals in two equal portions at 8 am and 4 pm. Drinking water was available at all time. The experiment lasted for two months. Milk production was recorded weekly. Milk samples were taken, fat, protein and lactose percentages were estimated. Fresh feces samples were collected for five days and dried in oven at 65°C for 24 h and mixed, then representative samples were taken. Chemical composition of representative samples was determined according to AOAC (1995) procedures. The digestibility was carried out by acid insoluble ash (AIA) as a natural marker according to Van Keulen and Young (1977) for determination DM in feces.

Procedures of determination acid-insoluble Ash (AIA): A 5 g sample (feed or feces) was placed in ashing crucible, then burned for 6 hours at 600°C . Ash was transferred to a beaker (500 ml) then 100 ml of 2 N HCl were added and boiled for 5 minutes then filtered through Whatman 541 filter paper and washed with hot distilled water. Filter paper was transferred back into crucible then burned for 6 hours at 600°C . Crucible was placed in a desiccator and weighed for determination of acid insoluble ash (AIA) according to the equation:

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$$\% \text{ acid insoluble ash (AIA)} = \frac{(\text{weight of crucible with Ash} - \text{weight of empty crucible})}{\text{Sample dry weight}} \times 100$$

Then average daily dried feces were calculated according to the equation:

$$\text{Average daily dried feces} = \frac{\text{Average daily dried feed intake} \times \% \text{ AIA in feed}}{\% \text{ AIA in feces}}$$

Or the dry matter digestibility% was calculated according to the equation:

$$\text{Dry matter (DM) digestibility} = \frac{\% \text{ AIA in feces} - \% \text{ AIA in feed}}{\% \text{ AIA in feces}} \times 100$$

Then average dried feces were calculated as follows:

Average daily dried feces = (averaged daily dried feed intake – (averaged daily dried feed intake × DM digestibility, %))

From average daily dried feed intake and average daily dried feces, digestion coefficients of OM, CP, CF and E.E were calculated. The NFE was calculated by difference. The Chemical composition of total mixed rations (TMR) as follows:

Table (1): Chemical composition of total mixed rations (TMR) on DM basis

Items	Ration 1 (control)	Ration 2	Ration 3
Dry Matter (DM)%	56.38	55.36	56.37
Organic Matter (OM)	93.45	92.23	88.19
Crude Protein (CP)	8.15	8.52	9.30
Ether Extract (EE)	5.22	5.57	5.65
Crude Fiber (CF)	11.44	12.16	11.76
Nitrogen Free Extract(NFE)	68.64	65.98	61.48
Ash	6.55	7.77	11.81

Ration 1: CFM + corn silage + berseem hay, Ration 2: CFM + corn silage + berseem hay + 70g Bentonite/cow/day, Ration 3: CFM + corn silage + berseem hay + 120g Bentonite/cow/day

Blood samples were collected from Jugular vein of animals fed the different rations. Serum was separated by centrifugation of the blood samples at 3000 rpm for 20 minutes and stored at -20 C° until analysis. Serum constituent measurements of urea(mg/dl), total protein (g/dl), alkaline phosphatase (ALP, units/l), aspartate transferase (AST, units/l) and alanine transferase (ALT, units/l) were calorimetrically determined using commercial kits (Egyptian Company for Biotechnology, S.A.E, and Diamond, D-P, International) as described by Young and Friedman (2001).

Statistical analysis:

All data were subjected to statistical analysis by using the general linear model procedure. Mean differences were compared using Duncan' multiple range test (Duncan, 1955). Data were analyzed using SPSS prog.

The mathematical model was as the follows:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:

Y_{ij} = Individual observation.

μ = The overall mean for the trial under consideration.

T_i = The effect of the i^{th} treatment.

e_{ij} = Random residual error.

RESULTS AND DISCUSSION

The chemical composition of Bentonite is shown in Table (2) and is nearly similar with data obtained by Kirovski *et al.* (2015), El-Saadany *et al.* (2003).

Table (2): Average chemical composition% of Bentonite

Silicon dioxide (SiO ₂)	52
Aluminum Oxide (Al ₂ O ₃)	22
Ferric Oxide (Fe ₂ O ₃)	4.25
Magnesium Oxide (MgO)	1.25
Calcium Oxide (CaO)	4
Sodium Oxide (Na ₂ O)	1.25
Potassium Oxide (K ₂ O)	1.3

Bentonite was added as 70g/cow/day in lactating cow ration (Table3) and significantly ($P < 0.05$) increased digestibility of OM, CP, CF and NFE. These results agreed with those obtained by Ghoniem *et al.* (2018) with lactating buffalos. EE digestibility was not

affected with Bentonite addition. Adding Bentonite as 120g/cow/day decreased OM digestibility. This is agreed with Fisher and MacKay (1983) who noticed that digestion coefficient of OM was significantly decreased with Bentonite addition at levels of 0.6 or 1.2% in lactating cow's rations containing grain mixture and corn silage than no addition of Bentonite. The total

digestible nutrients (TDN) of rations 2 was significantly ($P<0.05$) higher than that in control and ration 3. Adding Bentonite as 120g/cow/day significantly ($P<0.05$) decreased TDN which disagreed with Ghoniem *et al.* (2018). Adding Bentonite as 120g/cow/day significantly ($P<0.05$) increased DCP than other rations.

Table (3): Digestion coefficients and nutritive values (%) of experimental total mixed rations (TMR) with or without Bentonite addition by lactating cows

Items	Ration 1	Ration 2	Ration 3
Digestion coefficients, %			
Organic Matter (OM)	75.63±0.26 ^b	81.22±0.27 ^a	73.74±0.40 ^c
Crude Protein (CP)	71.25±0.59 ^b	71.38±0.51 ^a	74.63±0.48 ^b
Ether Extract (EE)	51.14±0.45 ^b	65.68±0.54 ^a	65.43±0.52 ^a
Crude Fiber (CF)	33.25±0.07	34.07±0.37	34.4±0.42
Nitrogen Free Extract(NFE)	72.52±0.57 ^b	80.48±0.28 ^a	72.53±0.41 ^b
Nutritive values, %			
Total Digestible Nutrients (TDN)	65.34±0.43 ^b	71.40±0.36 ^a	63.60±0.24 ^c
Digestible Crude Protein (DCP)	5.81±0.07 ^b	6.08±0.22 ^b	6.94±0.11 ^a

^{a,b,c} means in the same row with different superscripts are significantly different ($P<0.05$).

Ration 1: CFM + corn silage + berseem hay, Ration 2: CFM + corn silage + berseem hay + 70g Bentonite/cow/day and Ration 3: CFM + corn silage + berseem hay + 120g Bentonite/cow/day

The milk yield of lactating cows fed ration 2 (70g Bentonite/cow/day) was higher than that in control. These results agreed with those obtained by Ghoniem *et al.* (2018). The highest milk yield was recorded with ration 2 which increased by 10.11% than that in control as shown in Table (4). The differences of milk fat, protein, and lactose percentages among rations 1 (control), ration 2 and ration 3 were not significant (Table 4). These results agreed with those obtained by Jiang *et al.* (2018). The yield of milk fat of lactating cows fed ration 2 was higher than that in control, where protein yield of rations 2 was higher than other rations. Furthermore, adding Bentonite 70g/cow/day increased lactose yield.

The feed efficiency and feed conversion of rations 2 were better than control as shown in Table (4). These results were in agreement with Ghoniem *et al.* (2018) who found that feed efficiency as DM of lactating buffalos fed the ration containing Bentonite was better than that without Bentonite. The economic efficiency of rations 2 was higher than that in control and ration 3 (Table 4). The best economic efficiency was recorded with rations 2 (70 g Bentonite/cow/day). These results were agreed with Ghoniem *et al.* (2018) who found that economic efficiency was better of lactating buffalos fed Bentonite than control without Bentonite.

Table (4): Milk yield, FCM and Milk components of lactating cows fed experimental total mixed rations (TMR) with or without Bentonite addition

Items	Ration1	Ration2	Ration3
Milk yield (kg / cow /day)	29.76±1.32 ^{ab}	32.77±1.34 ^a	26.36±1.67 ^b
Difference than control, %	-	+10.11	-11.42
milk yield% from control	100	110.11	88.58
3.5% FCM yield (kg / cow /day)	30.09±0.95 ^b	33.23±0.4 ^a	26.91±0.76 ^c
Fat%*	3.57±0.24	3.59±0.15	3.63±0.10
Protein %*	2.67±0.21	2.72±0.10	2.71±0.23
Lactose%*	3.84±0.03	3.82±0.03	3.86±0.05
Fat yield (kg)	1.06	1.18	0.96
Protein yield (kg)	0.79	0.89	0.71
Feed efficiency (Kg milk/ Kg DM)	1.43	1.57	1.26
Feed conversion (Kg DM /Kg milk)	0.70	0.63	0.79
Economic efficiency	2.31	2.54	2.04

^{a,b,c} means in the same row with different superscripts are significantly different ($P<0.05$)

* No significant differences of percentages of fat, protein among treatments

Table (5): Blood urea (mg/dl), total protein (g/dl), alkaline phosphatase (units/l) and liver enzymes (units/l) of lactating cows fed experimental total mixed rations (TMR) with or without Bentonite and Zeolite additives

Item	Ration 1	Ration 2	Ration 3	Normal range
Urea (mg/dl)	28±0.58	26±0.89	23±0.58	6-27
Total protein (g/dl)	8.5±0.73	8.1±0.32	8.4±0.26	5.7-8.1
Alkaline phosphatase (units/l)	136±2.60	91±2.02	105±3.18	0-500
ALT (units/l)	23±0.89	23±0.88	26±0.98	11-40
AST (units/l)	84±1.73	91±1.53	85±1.76	78-132

All values of blood urea, Alkaline phosphatase, AST and ALT enzymes in all groups in this study are shown in Table (5) and lie within the normal levels as explained by Jackson and Cockcroft (2002).

CONCLUSION

From the results obtained in this study it could be concluded that the adding Bentonite (70 g Bentonite/cow/day) in rations of high yielding lactating cows led to improved digestibility, feed conversion and increased milk and fat yields.

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تأثير إضافة البنتونيت علي محصول اللبن و تركيب اللبن و معامل الهضم و القيم الغذائية في أبقار الهولستين

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الغرض من إجراء هذه الدراسة هو معرفة تأثير إضافة البنتونيت في علائق أبقار اللبن علي محصول اللبن و تركيب اللبن وكذلك معامل الهضم والقيم الغذائية وأيضا تركيزات اليوريا وإنزيم الفوسفاتيز القاعدي والبروتين الكلي وإنزيمات الكبد في سيرم الدم. ٧٢ بقرة من أبقار الهولستين تزن في المتوسط ٦٥٠ كجم تم توزيعهم عشوائيا علي ثلاث مجموعات بحيث احتوت كل مجموعة علي ٢٤ بقرة و تم تغذيتهم كالتالي: المجموعة الأولى تناولت علف كنترول بدون إضافات والمجموعة الثانية تناولت العلف إضافة ٧٠ جرام بنتونيت لكل بقرة في اليوم والمجموعة الثالثة تناولت العلف مع إضافة ١٤٠ جرام بنتونيت لكل بقرة في اليوم. استمرت التجربة لمدة شهرين. تم تغذية الأبقار علي TMR مكون من مخلوط علف مركز وسيلاج الذرة ودريس البرسيم. تم تسجيل إنتاج اللبن وتم اخذ عينات من اللبن و تقدير النسب المئوية البروتين والدهن واللاكتوز. تم اخذ عينات من العلف والروث وجفت علي ٦٥ درجة مئوية لمدة ٢٤ ساعة و تم اخذ عينات ممثلة منها لإجراء التحليل الكيماوي. و كانت أهم النتائج المتحصل عليها كالتالي: إضافة الزيوليت بمعدل ٨٠ جرام/ بقرة/ يوم أدت إلي زيادة معنوية في معامل هضم المادة العضوية والبروتين الخام والألياف الخام والمستخلص الخالي من النيتروجين. إضافة البنتونيت بمعدل ١٢٠ جرام/بقرة/يوم أدت إلي تقليل معامل هضم المادة العضوية. أدت إضافة البنتونيت بمعدل ٧٠ جرام/بقرة/ يوم إلي زيادة في محصول اللبن و محصول البروتين والدهن واللاكتوز. وبشكل عام ظلت تركيزات اليوريا والفوسفاتيز القاعدي والبروتين الكلي و إنزيمات الكبد في سيرم الدم ضمن المستويات الطبيعية.