Effects of Dietary Zeolite Supplementation on Milk Yield, Milk Composition, Digestion Coefficients and Nutritive Values in Holsten Cows

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Abstract: The purpose of this study was to determine the effects of Zeolite inclusion on lactating dairy cow's ration on milk yield, milk composition as well as digestion coefficients, nutritive values, blood urea, alkaline phosphatase, total protein, and some liver enzymes. The experimental work lasted for two months. Seventy-two Holstein Frisian cows with average weight 650 ± 5 kg were randomly divided into three groups (24 cows each). Every group was fed one of three rations as follows: in ration-1 group (control), cows were fed on a Total Mixed Ration (TMR) without any Zeolite addition, while rations-2 and -3 were supplemented with 80 and 140 g. Zeolite/cow/day, resp. The TMR ration consisted of concentrate feed mixture (CFM), corn silage and clover hay. Milk production was recorded weekly, and evaluated for fat, protein and lactose values and percentages. Fresh feces samples were collected for five consecutive days and dried in oven at 65°C for 24 hrs., then pooled together, and stored in plastic bags and representative samples were taken for chemical analysis. Adding Zeolite (80 G. Cow/Day) Significantly ($P \leq 0.05$) Increased Organic Matter (OM), Crud Protein (CP), Crud Fiber (CF), Ether Extract (EE), Nitrogen Free Extract (NFE), Digestibility, Total Digestible Nutrients (TDN) and Digestible Crud Protein (DCP). Milk protein, fat and lactose percentages were insignificantly and slightly affected by Zeolite additions. Furthermore, milk yield, Fat Corrected Milk (FCM), fat, protein, and lactose (Kg) of lactating cows was increased by adding Zeolite to basal ration. Generally, all values of blood urea, Alkaline phosphatase, AST and ALT enzymes in all groups in this study displayed approximately normal levels and did not seem to alter with Zeolite supplementation.

Keywords: Zeolite, lactating cows, milk yield, milk composition, AST and ALT enzymes

INTRODUCTION

The increase in the genetic potential of dairy cows has led to the massive use of concentrates in their ration to meet their escalating requirements. The increase in using concentrates in total mixed ration (TMR) has caused several problems such as decreased milk fat, lower fiber digestibility, and increased herd health problems related to acid-base disturbances. In order to alleviate or prevent metabolic disorders that are associated with the consumption of high concentrate diets by dairy cows, the inclusion of dietary buffers (*e.g.* sodium bicarbonate) has become a common and accepted practice. Although these mineral additives have received widespread usage, their inclusion into the diet is expensive for the producer. Therefore, some experiments have been conducted to using cheaper minerals that exhibit the same mode of action such as clay Zeolites (Khachlouf *et al*., 2018). Zeolites a crystalline, hydrated aluminosilicates, and having infinite three-dimensional structures, were discovered in the year 1756. They are further characterized by an ability to lose and gain water reversibly and to exchange constituent cations without major change of structure and the cations are usually exchangeable at low temperature below 100°C (Lijima, 1980).The objective of this work was to investigate the effects of adding Zeolite 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. Seventy-two Holstein Frisian cows with average weight 650±5 kg were randomly divided into three groups (24 cows each). Every group was fed one of three rations as follows: in ration-1 group (control), cows were fed on a Total Mixed Ration (TMR) without any Zeolite addition, while rations-2 and -3 were supplemented with 80 and 140 g. Zeolite/cow/day, resp. The TMR ration consisted of concentrate feed mixture, corn silage and clover hay. Milk production was recorded, and evaluated for fat, protein and lactose values and percentages. The feed requirements were calculated according to NRC (2001). TMR was daily offered to ~~the~~ animals in two equal portions at 8 am and 4 pm. Drinking water was available at all times. The experiment lasted for two months. Milk production was recorded weekly, and evaluated for fat, protein and lactose values and percentages. 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 ash crucible, then burned for 6 hours at 600^{o} 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^{o} 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, then 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	56.17	56.07
Organic Matter (OM)	93.44	93.19	89.23
Crude Protein (CP)	8.14	8.66	8.12
Ether Extract (EE)	5.21	5.35	5.72
Crude Fiber (CF)	11.44	12.88	12.28
Nitrogen Free Extract (NFE)	68.64	66.30	63.11
Ash	6.54	6.81	10.77

Ration-1: concentrate feed mixture (CFM) + corn silage + berseem hay
Ration-2: CFM + corn silage + berseem hay + 80 g. Zeolite/cow/day
Ration-3: CFM + corn silage + berseem hay + 140 g. Zeolite/cow/day

The chemical composition of Zeolite is shown in Table (2) and is nearly similar with data obtained by Katsoulos *et al*. (2006).

Table (2): Percentages of elements proximate analysis of Zeolite on Dry Matter (DM) basis

Element	%
Aluminum (Al)	8.41
Silica (Si)	55.79
Potassium (K)	11.05
Calcium (Ca)	6.81
Thallium (Ti)	1.04
Manganese (Mn)	0.34
Iron (Fe)	15.22
Zink (Zn)	0.07
Rubidium (Rb)	0.10
Strontium (Sr)	0.16
Yttrium (Y)	0.12
Zirconium (Zr)	0.62
Niobium (Nb)	0.11
Cadmium (Cd)	0.09

The analysis was carried out in Center Laboratory of Elemental and Isotopic Analysis, Atomic Energy Authority-Nuclear Research Center, Cairo, Egypt.

Statistical analysis:

All data were subjected to statistical analysis by using SPSS 26 (2020). Mean differences were compared using Duncan's Multiple Range test (Duncan, 1955).

The mathematical model was as 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

As shown from Table (3), the organic matter (OM) digestibility of rations supplemented with Zeolite was significantly ($P \leq 0.05$) higher than that in controls. The CP and EE digestibility significantly ($P \leq 0.05$) increased in rations-2 and -3 than that in controls. These results agreed with Forouzani *et al.* (2004). The CF digestibility of rations-2 and -3 were significantly ($P \leq 0.05$) higher than that in controls. The NFE digestibility of rations 2 was significantly ($P \leq 0.05$) higher than that in controls. The total digestible nutrients (TDN) of rations-2 and -3 was significantly ($P \leq 0.05$) higher than that in controls.

Table (3): Digestion coefficients, nutritive values, and blood constituents of experimental total mixed rations (TMR) with or without Zeolite additives by lactating cows

Items	Ration1	Ration2	Ration3
Digestion coefficients, %			
OM	75.63±0.26^{c}	82.70±0.11^{a}	80.58±0.33^{b}
CP	71.25±0.59^{c}	75.72±0.45^{a}	71.34±1.02^{b}
CF	51.14±0.45^{b}	65.27±0.70^{a}	59.96±0.79^{a}
EE	33.25±0.07^{c}	38.07±0.96^{a}	38.67±0.89^{b}
NFE	72.52±0.57^{b}	81.38±0.16^{a}	79.57±0.32^{b}
Nutritive values, %			
TDN	65.34±0.43^{c}	73.50±0.28^{a}	68.34±0.30^{b}
DCP	5.81±0.07^{b}	6.56±0.12^{a}	5.79±0.15^{b}

^{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 + 80g Zeolite/cow/day and
Ration-3: CFM + corn silage + berseem hay + 140g Zeolite/cow/day

As shown from Table (4), zeolite was added by 80 and 140 g/cow/day and insignificantly increased milk, protein, fat, and lactose yields and FCM. Differences of milk fat, protein, and lactose percentages among rations 1 (control), ration-2 and ration-3 were not significant. These results agreed with those obtained by Khachlouf *et al*. (2019). The yield of milk fat of ration-2 was higher than that in control, protein yield of rations 2 was higher than other those in other rations.

As shown from Table (4), feed efficiency and feed conversion of rations-2 and -3 were better than that in controls. These results were in agreement with Nadziakiewicza *et al.* (2019) who mentioned that feed conversion was better with clay addition. The economic efficiency of rations2 and 3 was higher than that in controls.

Table (5) revealed that all values of blood urea, alkaline phosphatase, AST and ALT enzymes in all groups were within the normal levels as explained by Jackson and Cockcroft (2002).

CONCLUSIONS

From the results obtained in this study it could be concluded that supplementing Zeolite (80 or 140 g./cow/day) in the rations of high yielding lactating cows led to improve digestion coefficients, feed conversion, milk production and fat yields.

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

Items	Ration-1	Ration-2	Ration-3
Milk yield (kg/cow/day)	29.76±1.32	30.59±0.12	31.12±1.12
Difference than that in controls, %	-	+2.79	+4.57
milk yield % from control	100	102.79	104.57
3.5% FCM yield (kg/cow /day)	30.09±0.95	31.02±0.31	31.12±0.5
Fat%*	3.57±0.24	3.58±0.12	3.50±0.28
Protein %*	2.67±0.21	2.60±0.24	2.87±0.12
Lactose%*	3.84±0.03	3.80±0.05	3.72±0.05
Fat yield(kg)	1.06	1.10	1.09
Protein yield(kg)	0.79	0.79	0.89
Lactose yield(kg)	1.14	1.16	1.16
Feed efficiency (Kg milk/Kg DM)	1.43	1.46	1.48
Feed conversion (Kg DM/Kg milk	0. 70	0.68	0.67
Economic efficiency	2.31	2.34	2.36

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 Zeolite and Zeolite additives

Item	Ration-1	Ration-2	Ration-3	Normal* range
Urea (mg/dl)	28±0.58	25±0.89	29±0.58	6-27
Total protein (g/dl)	8.5±0.73	8.3±0.20	7.9±0.18	5.7-8.1
Alkaline phosphatase (units/l)	136±2.60	96±1.76	138±2.91	0-500
ALT (units/l)	23±0.89	29±1.45	32±1.20	11-40
AST (units/l)	84±1.73	90±2.08	120±2.08	78-132

* normal range according to Jackson and Cockcroft (2002).

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تأثير إضافة الزيوليت علي محصول اللبن وتركيب اللبن و معامل الهضم و القيم الغذائية في أبقار الهولستين

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الغرض من إجراء هذه الدراسة هو معرفة تأثير إضافة الزيوليت في علائق أبقار اللبن علي محصول اللبن وتركيب اللبن وكذلك معامل الهضم و القيم الغذائية وأيضا تركيزات اليوريا وإنزيم الفوسفاتيز القاعدي و البروتين 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 الأولي تناولت علف كنترول بدون إضافات والمجموعة الثانية تناولت العلف إضافة ٨٠جرام زيوليت لكل بقرة في اليوم و المجموعة الثالثة تناولت العلف مع إضافة ١٤٠جرام زيوليت 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 وتقدير النسب المئوية البروتين والدهن واللاكتوز. تم اخذ عينان من العلف والروث وجففت علي ٦٥ درجة مئوية لمدة ٢٤ ساعة وتم اخذ عينات ممثلة منها لإجراء التحليل الكيماوي. وكانت 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 الأثيري وكذلك أيضا زيادة معنوية في مجموع القيم الغذائية المهضومة والبروتين الخام المهضوم. تأثرت النسب المئوية لبروتين ودهن ولاكتوز اللبن بشكل طفيف بإضافة الزيوليت. كما حدثت زيادة في محصول اللبن ومحصول البروتين والدهن واللاكتوز بإضافة الزيوليت إلي العلائق. وبشكل عام ظلت تركيزات اليوريا والفوسفاتيز القاعدي والبروتين الكلي وإنزيمات الكبد في سيرم الدم ضمن المستويات الطبيعية.