# Effect mineral mixture with a buffering properties on production and quality milk of cows in heat stress conditions

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*Scientific paper*
*UDC:351.777.3.127.137*

## INTRODUCTION

Disorders in the process of food digestion in the rumen often manifest as acidosis which leads to a number of pathological processes among which are morphological changes of the rumen mucosa, decreased motility, poor food passage, as well as ruminitis and parakeratosis. As a result of the above mentioned is a significantly decreased resorptive surface of the rumen and reduced absorption of the products of food digestion. Bearing in mind that acidosis is accompanied by poor appetite it is clear that the end result of these disorders is a reduction in milk production. Rumen acidosis is characterized by an excessive accumulation of lactic acid as the result of a diet rich in easily digested carbohydrates, excessive acidic and moist feeds, insufficient fibers in the diet, few meals and long periods between meals. In such cases there is insufficient production of saliva, which is the natural regulator of the electrochemical reaction in the rumen. These problems are specially enhanced in high yielding dairy cows in the first phase of lactation when they have to consume large quantities of concentrated feeds and in the summer months, specially when kept in tie stalls when high ambient temperatures and inadequate microclimate in the stable result sudden appetite loss. Besides, during the high summer temperatures food is at a higher risk to become spoiled, silage ferments, moulds which produce mycotoxins are produced and rumen microflora is negatively affected which makes the problem even worse.In the state of acidosis the number of bacteria producing lactic acid in the rumen progressively increases, and the number of bacteria which use up this acid is on the decrease. *Streptococcus bovis* produces lactic acid in the process of carbohydrate metabolism and quickly becomes the dominant microorganism in the rumen's content. During this process the number of *Megasphera elsdenii, Selenomonas ruminantium* and other bacteria which use lactic acid is on the decrease. By further lowering the electrochemical reaction the reproduction of *Streptococcus bovis* decreases and lactobacilli continue to produce lactic acid thus contributing to a further increase in its concentration in the rumen. The lowest pH values in the rumen are recorded during night time and in the early morning hours. The deviation of the pH value from its normal physiological range (6.2 – 6.8) results in an adverse impact on the development of the rumen microflora and thus the processes of digestion, which negatively affects the production and fat content in the milk *(Horea et al., 2006)*. The key factor for the preservation of the pH balance of the rumen is the bicarbonate buffer. However, under conditions of rumen acidosis there is a decreased production of saliva and hence less bicarbonate reaches the rumen. The efficacy of the bicarbonate is than almost negligible due to the present atonia of the rumen and insufficient mixing of the saliva and rumen content. Due to the state of atonia there is a decreased degree of resorption of acids and the role of the bicarbonate buffer is almost minimized. Under conditions of heat stress, during high summer temperatures (>27 $^{o}$C) due to panting there is increased salivation which results in a loss in calcium, potassium, sodium and magnesium cations which are necessary for the maintenance of the acid-base status of the animal [14].

Buffers which have the capability to neutralize the increased acidity are used for the maintenance of the rumen's pH. Some minerals, such are bentonite and zeolite belong to the group of natural alumosilicates which have a marked surface activity which is the result of superficial electricity. Their chemical activity can be controlled and directed, which gives them the chance to be applied in the diet of domestic animals. Both of these minerals act as buffers. In an acidic environment by cation exchange they bind $H^+$ and release a caption which is naturally found in an exchangeable position, thus resulting in increased pH. These changes occur only as long as the neutral environment (pH 7) is achieved. When the pH is over pH 7, the presence of these minerals leads to a decrease in

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*Paper received: 10. 07. 2013.*

pH down to the neutral stage. Rivera et al. [11] have confirmed that zeolite has a tendency to neutralize the water solutions, regardless if it serves as a donor or acceptor of protons, which indicates on its amphoteric character. The use of only magnesium oxide or sodium bicarbonate can result in an increased rumen pH which is not desirable. After their reduction in the rumen there is a subsequent pH decrease below optimal values. The application of a mixture containing bentonite, zeolite, magnesium oxide and sodium bicarbonate creates conditions for the maintenance of a stable pH in the rumen within the optimal range for a period of 24 hours. Bentonite and zeolite successfully absorb micotoxins (aflatoxin), excess ammonia, heavy metals, radio nucleotides and excess water. Bentonite swells and thus slows food passage through the digestive tract which results in its improved digestion and utilization. Such additives are added to the feed mixture in a quantity of 1 – 2% [1, 4, 5, 9, 10].

## MATERIAL AND METHODS

The study was conducted from June to November on two groups cows: the control-C (129) and experimental-E (119. The cows were in linked system of keeping. Groups were formed according to “couple“ system (two cows with similar characteristics) after 7-10 days calving and allotted to one of two stables. The given meals were identical with the difference that in the complete feed mixture in group E a mineral mixture with buffering properties was added in the quantity of 1%. The mixture was produced at the Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, Serbia. The mixture composition is based on natural bentonite, natural zeolite, magnesium oxide and sodium bicarbonate. Cows were fed twice a day (6-7 AM and 5-6 PM). Feedstuff composition based on the proportion of dry matter of individual feeds in dry matter of the given meal, chemical composition of the meal, and composition of complete feeds mixtures is given in tables 1 and 2.

*Table 1 - Dry matter feeds in dry matter of complete feed meal (%) and chemical composition*

| Indicator | C group | E group |
|---|---|---|
| Alfalfa hay | 17,35 | 16,59 |
| Alfalfa haylage | 11,09 | 10,90 |
| Corn plant silage, 30% SM | 28,61 | 29,71 |
| Brewer’s trope | 3,73 | 3,57 |
| Extruded soybean | 6,81 | 6,51 |
| Complete feed mixture C | 32,41 | - |
| Complete feed mixture E | - | 32,72 |
| **Total** | **100,00** | **100,00** |
| Dry matter, kg | 19,82 | 20,73 |
| NEL, MJ | 127,58 | 132,89 |
| Proteins,% SM | 16,65 | 16,78 |
| Fat,% SM | 4,43 | 4,39 |
| Cellulose, % SM | 18,06 | 17,85 |
| Ca, % SM | 0,89 | 0,91 |
| P, % SM | 0,66 | 0,65 |
| K,% SM | 1,50 | 1,48 |
| Na,% SM | 0,13 | 0,15 |
| Mg,% SM | 0,34 | 0,39 |
| Cl,%SM | 0,45 | 0,44 |
| S,% SM | 0,30 | 0,29 |
| **BAKO mEq g/SM** | **+126,45** | **+139,09** |

*Table 2 - Composition of complete feed mixtures*

| Indicator | C group | E group |
|---|---|---|
| Corn grain groats | 26,30 | 26,30 |
| Oat grain groats | 20 | 20 |
| Sunflower meal | 42 | 42 |
| Flour meal | 8 | 7 |
| Dicalcium phosphate | 1,40 | 1,40 |
| Chalk | 1,60 | 1,60 |
| Vitamin & micromineral mixture | 0,70 | 0,70 |
| Mineral mixture with buffer | 0 | 1 |
| **Total** | **100** | **100** |

Control of milk yield and determination of the chemical composition of milk was carried out once a month. The balance of captions and anions in the meals (BAKO) was determined using the formula proposed by [2]. Feed consumption was estimated daily. The pH of the rumen content was measured at the end of the trial. Samples of ruminal contents were collected by probe 0.5 h before morning feeding and 5 h after the morning feeding from 10 cows in each group. The electrochemical reaction in the samples of rumen contents was measured by a pH meter (WTW 330i) immediately after sampling. Chemical analysis of the milk samples was performed with an automatic machine Milkoscan. The air temperature was measured daily (1-2 PM) with a mercury thermometer. Outdoor temperature was measured in the shade at 10 meters distance from the stables at a height of 150 cm from the soil, and the stable temperature was recorded in the middle of the building, at 100 cm above the feeding table. The average outdoors air temperature between 1 – 2 PM was 32 $^0$C and the temperature in the stables was 36$^0$ C. Statistical data analysis was done with *StatSoft. Inc.: Statistica. Data Analysis Software System. Version 8.0, 2008.*

## RESULTS AND DISCUSSION

The milk yield in the period June – August (table 3) in group E was higher by 1.99 kg or 8.16% ($p<0.05$). For the same period a relative (%) and absolute (kg) increase in fat content and produced fats and proteins in the milk ($p>0.05$) was recorded. The average outdoors air temperature between 1 – 2 PM was 32 $^0$C and the temperature in the stables was 36 $^0$C.

*Table 3 - The Milk yield and composition of milk*

| | June – August | | September – October | | June – November | |
|---|---|---|---|---|---|---|
| **Indicator** | **C group** | **E group** | **C group** | **E group** | **C group** | **E group** |
| Milk, kg/cow/day | 24,36 | 26,35* | 24.76 | 25.14 | 24.56 | 25.75 |
| Milk fat, % | 3,31 | 3,40 | 3.33 | 3.49 | 3.32 | 3.45 |
| Protein, % | 2,80 | 2,84 | 2.92 | 2.93 | 2.86 | 2.89 |

*(p<0,05)

The milk yield in the period September – October in group E was higher by 0.38kg, or 1.53% (0<0.05). Differences between group C and E were significantly smaller.

The quantity of produced milk fats and proteins in this period was, as in June – August insignificantly higher in group E ($p>0.05$). The average outdoor air temperature for the period between 1-2 PM was significantly lower compared to the previous period and measured 21$^0$ C, the stable air temperature was 25 $^0$C. The milk yield during the period June – November, and the entire trial period was higher in group E by 1.19kg, or 4.85% ($p<0.05$). The quantity of produced milk fat and protein was not significantly higher in group E ($p>0.05$).

Comparing the results achieved in the produced quantity of milk in the period June-August and September to November can be concluded that the studied mineral mixture (with buffering action) effectively influenced the milk yield of cows in the warmest period of the year, when the cows were apparently exposed to the impact of heat stress as evidenced by temperatures which were for a longer period of time above 27 $^0$C.

Nikkhah et al. [7], found that the use of zeolite and sodium bicarbonate in the diet of cows individually or in combination, increases the milk yield by 0.7 -2 kg ($p <0.05$), while fat and protein in the milk increased by 0.12 to 0.26, respectively, equivalent to 0.04 to 0.06 percentage points. According to [1], the addition of mineral mixtures based on magnesium oxide, sodium bicarbonate, bentonite and organozeolite (modified natural zeolite) in the first 100 days of lactation cows influenced the increase of milk yield, corrected to 4% milk fat, by 0.43 kg / day or 1.59%. Average milk fat content in milk was higher in the experimental group by 0.29 percentage points (3.29 and 3.58%). *Horea et al. (2006)* when using the same mineral mixture as in the present study, found milk production to be increased by 1.5 kg / day or 6.17% with an increase in milk fat content from 3.39 to 3.53%, and a slight increase protein from 2.88 to 2.89%. Similar results in terms of milk yield when using mineral mixtures of the same composition were recorded by [9]. In doing so, the differrences in the quantity of milk between the control and experimental groups of cows (30th 60th and 90th day of the trial) were statistically significant ($p <0.05$). Bergero et al. [3] found that the addition of 250/head /day of zeolite (clinoptilolite 64%) in the diets of cows increased the amount of milk by 1.47 kg/day or 12.47%, but did not have a major influence on the pH of the rumen contents, the amount of ammonia and content of volatile fatty acids present in the rumen. The results of [6] should be emphasized as they studied the effects of 1.8% and 3% zeolite in the meal DM during a 21 day trial on dairy cows. The authors determined a significant decrease in rumen pH (from 6.78 to 6.71 and 6.34). Results of the effects of mineral mixture with buffering effect, (of the same composition, with the same rations and cows, as in our research,) on the pH of the rumen contents of cows were reported by *Horea et al. (2006) (table 4)*

*Table 4 - Rumen pH values*

| Time of sampling | C group | E group |
|---|---|---|
| 0.5 h before feeding | 6,25 ± 1,5 | 6,79 ± 0,89* |
| 5 h after feeding | 6,01 ± 2,8 | 6,92 ± 1,01 |

According to research by the authors the investigated use of mineral mixture had a beneficial effect on the pH of the rumen contents before (6.79) and after the morning feeding (6.92). This clearly shows that the presence of mineral mixture in the rumen contents maintained a stable electrochemical reaction continuously within in the physiological range. Also in this group of cows there were small individual differences, which was not the case in cows in group C, where the pH of the rumen content was below the physiological limits and was 6.25 before feeding and 6.01 after feeding. In such cases the animals did not take enough food in the morning and usually large amounts of food were left over up to the next meal. Similar results, when using the same mineral mixture in the diet of cows in early lactation, were found [1, 15], found that zeolite and sodium bicarbonate, administered simultaneously, increased the pH in the rumen liquor from 6.16 to 6.50. Similar results were determined and [9]. The pH of the rumen contents of the control and experimental groups of cows on the 60th day was 6,22:6.77 and on the 90th 6.31: 6.68 (p <0.05).

In addition to causing qualitative and quantitative changes in bacterial flora in the rumen, the low pH affects the abundance and mobility of infusoria in the rumen [8]. In the study conducted on native rumen contents were found significant differences between the presence of infusoria between group C and E. Cows in group C had significantly fewer infusoria in the visual field small and medium-sized (n = 8), and the number of large infusoria in the visual field was very small (1 to 2). In E group cows three times more infusoria in the visual field (24) was found and all three types were present: small, medium and large. Unlike cows in group C, where the infusoria of the rumen contents were poorly motile, cows infusoria in group E were very mobile. Radivojević et al. [10] used a similar mineral mixture in the experimental group of cows and found a higher pH value of rumen contents and a number of medium and large infusoria.

## CONCLUSION

The quantity of milk in the hottest summer months (June - August) in group E was higher by 1.99 kg or 8.16% (p <0.05). In the period from September to November the quantity of milk in group E also increased, but differences between groups of 0.38 kg or 1.53% in favor of group E were lower (p> 0.05). The quantity milk for the period June - November was higher in group E by 1.19 kg or 4.85% (p <0.05). In the same period, the differences in content and amount of milk fat and protein were slightly higher in group E (p> 0.05).

The pH of the rumen was higher in group E, and before the morning feeding was 6.25 and 6.79 (p> 0.05), or after the morning feeding 6.01 and 6.92 (p <0.05). In the rumen in the experimental group an increased number of infusoria with greater mobility was described. It can be concluded that the investigated mineral mixture with a buffering properties has a positive impact on the stability and the pH of the rumen microbial growth, which contributes to the creation of favorable conditions for the digestion and feed utilization, and thus greater milk yield and production of milk fat and protein.


*Acknowledgement*

*This study was realized within the TR 31003 and TR 34013 projects framework, supported by the Ministry of Education and Science, Republic of Serbia*


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## ABSTRACT

EFFECT MINERAL MIXTURE WITH A BUFFERING PROPERTIES ON PRODUCTION AND QUALITY MILK OF COWS IN HEAT STRESS CONDITIONS

*This paper presents the results of investigations on the effects of a mineral mixture with a buffering properties, on the quantity and composition of milk, pH value of cow's rumen contents, number and motility of microorganisms. The study was conducted from June to November on two groups cows: the control-C (129) and experimental-E (119). The cows were in linked system of keeping. Groups were formed according to "couple" system (two cows with similar characteristics) after 7-10 days calving and alloted to one of two stables. The given meals were identical with the difference that in the complete feed mixture in group E a mineral mixture with buffering properties was added in the quantity of 1%. The mixture was produced at the Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, Serbia. The mixture composition is based on natural bentonite, natural zeolite, magnesium oxide and sodium bicarbonate,*

*The milk yield during the hottest summer months (June – August) in group E was higher by 1.99 kg or 8.16% ($p<0.05$). During the period (September – November) the milk yield in this group was also higher, but insufficiently to make the difference (0.38kg or 1.53%) between the C and E group ($p>0.05$). The differences in the content and yield of milk fat and protein, (% and kg) were insignificantly higher for group E during both investigation periods. The pH value of the rumen content was higher in group E and was within the optimal physiological limits. Before the morning meal the values for group K and E were 6.25 : 6.79 ($p>0.05$), respectively. After the morning meal the corresponding rumen pH values were 6.01 : 6.92 ($p<0.05$).The number and motility of the infusoria present in the rumen of group E cows was increased. That the studied mineral mixture with buffering propreties has a positive effect on the pH stability and development of the microorganisms present in the rumen under conditions of heat stress. This contributes to the arousal of favorite conditions for food digestion and utilization and hence to higher milk production and increased fat and protein content.*

**Key words:** *acidosis, cow, rumen, buffer*