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SATISFACTION OF Cu AND Zn REQUIREMENTS OF DARIY COWS FED DIFFERENT RATIONS IN WINTER TIME NUTRITION

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SUMMARY

An experiment was carried out to study Cu and Zn nutrition of dairy cows fed different winter-type rations. The rations consisted of typical forage and concentrated feeds (maize silage, meadow hay, brewers grain, sunflower meal, sugar beet pulp and concentrate mixture), all without mineral supplement. The Cu concentrations were 12.50 ppm (ration A); 13.73 ppm (ration B); 12.28 ppm (ration C); and 14.04 ppm (ration D); and Zn concentrations were 67,56 ppm; 70.26 ppm; 58.97 ppm and 70.13 ppm in rations A,B,C, and D, respectively. All rations had higher concentrations of Cu and Zn, as compared to INRA (88) recommendations. The content of trace elements in milk of tested cows were 1.15 ppm and 4.11 ppm (A); 0.89 ppm and 3.40 ppm (B); 0.36 ppm and 3.25 ppm (C); 1.38 ppm and 3.86 ppm (D) for Cu and Zn content, respectively, and there were no statistically significant differences between treatments for trace elements.

The difference of Cu balance in treatment D (10.06 mg/day) were significantly higher compared to other treaments (3.00 mg - A; 4.96 mg- B and 5.47 mg-C)

The mean value of daily Zn balance (43.34 mg - A; 26.44 mg -B; 16.90 mg -C; and 40.91 mg -D) were not statistically significant between treatments (P=0.531).

Keywords: Copper, zinc, dairy cows, balance

INTRODUCTION

All *forms* of living matter require inorganic elements, or minerals, for their normal life processes. Mineral elements exist in the cells and tissue of the animal body in a variety of functional chemical combinations and in specific concentrations which vary with the element and the tissue. The concentrations must be maintained within quite narrow limits, or normal ranges, if the functional and structural integrity of the tissues is to be safeguarded and the growth, health and productivity of the animal are to remain unimpaired. The main three types of trace minerals function found in animal body are structural, electrolytic and enzymatic. Large numbers of livestock in many parts of the world consume diets that do not meet these mineral requirements. As a consequence, nutritional disorders arise which range from acute or severe mineral deficiency or toxicity disease to mild and transient conditions difficult to diagnose with certainty, and are expressed merely as unsatisfactory growth, production and fertility. Mild or marginal deficiencies or toxicities of this nature are of great importance in the nutrition of livestock because of their extent and the ease with which they can be confused with the effects of semistarvation due to underfeeding, protein deficiency and various types of parasitic infestation.

The aim of the study is to investigate Cu and Zn content in various feedstuffs used in dairy cows' nutrition during winter time. Additionally, the aim is to investigate apparent availability of those minerals obtained from different winter time rations.

MATERIALS AND METHODS

Experimental animals and procedure

Sixteen Holstein cows with body weight 610±22 kg, age 46±3.5 months and producing 14.20±0.45 kg milk, divided into four groups are used in the study with the aim to investigate Cu and Zn balances. The balances are estimated as differences between the amount of minerals consumed and their amounts in detected feces, urine and milk.

The experiment consisted of a preparation phase (21 days) and a collecting phase (7 days).

Experimental rations

Each group were fed with differing rations consisting of typically used feecistuffs in winter time dairy cows' diet (Table 1).

Table 1. The ingredient and nutrient composition of experimental rations*

	Rations			
	A	B	C	D
Ingredient				
Corn silage, %	46016	49.5	52.81	45.37
Natural grass hay, %	1.91	12.71	13.61	5.89
Brewer's grain, %	12.79	6.82	-	-
Sunflower solvent extracted with hulls, %	-	6.32	13.55	8.73
Sugar beet pulp, %	-	-	-	11.38
Concentrate mixture, %	29.14	24.91	20.02	28.64
Nutrient composition				
- Dry matter, %	31.62	33.17	35.11	38.28
- Crude fiber, %	20.08	21.72	23.62	20.11
- Crude protein, %	11.88	12.12	12.40	11.55
GE, MJ	18.32	18.25	18,17	18.02
ME, MJ	10.92	10.88	10.79	10.76
q factor	0.596	0.596	0.594	0.597
NEL, MJ	6.62	6.60	6.54	6.53
NEGF, MJ	6.71	6.69	6.62	6.62

* all values are expressed on dry matter basis

Sampling procedures and analytical methods

Feed, milk, feces and urine samples were taken daily during collecting phase and preserved. Dry matter, crude fiber and crude protein were determined to be present in the samples, according to Weende procedure. GE, ME, NEL and NEGF were estimated according to I N R A (1989) equations The samples preparation and Cu and Zn determination in feed, feces, urine and milk were assessed according to A 0 A C (1980) using Atomic Absorption Spectrophotometry (AAS).

Samples of feeds and faeces were prepared with a dry ashing procedure. Samples of t e urine were prepared consequent to evaporation. Samples were heated at 550°C for 8 to 12 hours then 10 ml of 6M HCl was added After the samples were boiled under controlled heat, filtrated through ashless filter paper and filled by ydestilled water to 100 ml. Cu and Zn, contents were read direcfly from digested volume to the AAS.

Statistical analysis

Statistical levels of the samples were tested using the ANOVA (S A 5, 1988) procedure, using "Statistic for Windows" - Stat. Soft., Inc. (1993).

RESULTS AND DISCUSSION

The Cu and Zn content in the investigated feedstuffs and experimental rations

The content of the investigated trace elements in sampled feedstuffs are shown in Table 2.

Table 2. Copper and Zinc content in investigated feedstuffs*

Feedstuffs	Cu, ppm	Zn, ppm
Corn silage	3.59	24.15
Natural grass hay	5.53	34.61
Brewer's grain	12.11	25.47
Sunflower solvent extracted with hulls	33.97	89.62
Sugar beet pulp	5.63	10.19
Concentrate mixture	29.61	168.17

* All values are expressed on dry matter basis

The variability of Cu and Zn content in forage is more wider compared to their contents in concentrates (McDwell, 1992). The different parts of dry matter from forage influenced on different concentrations of Cu and Zn in investigated rations (Table 3).

Table 3. Cupper and zinc content in investigated rations

	Rations			
	A	B	C	D
Cu, ppm	12,50	12.81	13.17	14.04
Zn, ppm	67.6	65.52	63.24	70.13

Cu content in investigated feedstuffs and rations

Concentrations of copper in crops and forages are dependent on plant species, soil factors, stage of maturity, crop management, yield and climate (McDowel l, 1992). Nutrition with these trace elements is complicated by the presence of other minerals (especially Mo and S) which strongly influence copper availability (Baker, 1995). Great variability of Cu content in forage has been by many ant ors as a result of the influence from the above mentioned factors. Investigated corn silage contained 3.59 ppm and natural grass hay contained 5.53 ppm of Cu. These results corresponded with the values reported by INRA (1989), McDonald (1995) and Paragon (1995). Cu concentrations in forage can not satisfy demand of dairy cows. Coic and Coppenet (1989) reported that average concentration of Cu in corn silage and natural grass hay was 4.5 ppm and dairy cows requirements are 10 ppm of Cu. Cu content in investigated brewer's grain (12.11 ppm) was below values reported by Paragon (1995) and McDonald (1995) which ranged from 25 to 70 ppm of Cu. Concentrations of Cu in used sugar beet pulp (5.63 ppm) and sunflower solvent extracted with hulls (3.97 ppm) corresponded with known literature values.

Because of small range between minimal requirement and toxicity levels of Cu in ruminant rations (this range is from 7 to 30 ppm, according INRA, 1989), property nutrition of ruminants with these minerals is very sensitive. The sample rations contained from 12,50 to 14,04 ppm of Cu. This content was higher than published recommendations (NRC, 1984; INRA, 1988; ARC, 1980 and Grace, 1989), but was closest to recommended values published in (ARC, 1980).

Crops are richer in Cu content than forage The highest level of concentrates as a percentage of total dry matter were found in ration D (48.74%) which elevated the level of Cu content in this ration (14.04 ppm). The smallest concentration of Cu is in ration A (12.50 ppm), and was due to the absence of sunflower solvent extracted with hulls which naturally is rich in copper.

Zn content in investigated feedstuffs and rations

Investigated corn silage contained 24,15 ppm Zn, natural grass hay 34,61 ppm, brewer's grain 25,47 ppm, sunflower solvent extracted with hulls 89.62 ppm, sugar beet pulp 10,91 ppm and concentrate mixture 168,17 ppm Zn. Values of Zn content in corn silage reported by NRC (1989), Miller, (1979), I NRA (1989), and McDonald (1995) corresponded with the Zn content in investigated corn silage while tested natural grass hay was slightly-richer in Zn content. Among other factors, content of zinc in hay depend on their concentrations in soils (Lamand, 1989) as well as of botanical structure of hays. INRA (1989), McDonald *et al.*(1995) and NRC (1989) reported that sugarbeet pulp contained 9.6 ppm, 11 ppm and 14 ppm of Zn respectively and concentration of Zn in brewers grain ranged from 25 ppm (McDonald *et al.*, 1995) to 80 ppm Zn (NRC,1989). These values corresponded with concentrations of Zinc in investigated brewer's grain and sugarbeet pulp.

Zinc concentration in plant protein sources is higher than in forages. Investigated sunflower solvent extracted with hulls contained 89~62 ppm of Zn. These values corresponded with known literature values (I NRA, 1989 and NRC, 1989).

Zinc deficiency in ruminants often passes unnoticed. The deficiency is more characteristic in young animals whereas in adult the symptoms are rarely obvious. Deficiency due to low dietary zinc or primary deficiency is rare but secondary deficiency arising from modification of zinc digestibility is more frequent (Laman (1989). Optimal concentrations of Zinc in dairy cow rations ranged from 25 to 50 ppm NRC, 1984; INRA, 1988; A R C, 1980). Toxicity levels are also different and ranged from 250 ppm of Zn (INRA, 1988) to 2000 ppm (Miller *et al.*, 1979). The concentrations Zn were similar in all tested rations except ration C which had lower Zn.

This fact is explained by higher concetration of forage in total dry matter of ration. It is known that forage is poorer in Zn content than concentrates. All experimental rations contained higher concentrations of Zn than optimal requirements but below toxic levels.

Cu and Zn content in milk of the experimental animals

The mineral composition of milk varies with the animal species, the stage of lactation and the nutrition of the lactating animal (Underwood, 1981). Cow's milk contains 7-8 gash where Ca and P are most representative while trace mineral content is relatively low.

The concentrations of Cu and Zn in milk of experimental animals are given in the Table 4.

Table 4. Cu and Zn content in the milk of experimental cows, mg/kg

	Rations					
	A	B	C	D	S.E.*	P**
Cu	1.153±0.45	0.885±0.39	0.356±0.02	1.379±0.15	0.17	0.186
Zn	4.110±0.31	3.403±0.43	3.250±0.56	3.856±0.28	0.20	0.461

* Standard error of the treatments
** level of significance

Milk and milk products are poor in copper content but during processing and storage Cu content can significantly increase due to contamination with metals (McDowell, 1992). Normal Cu content in cow's milk ranges from 0.02 to 0.2 mg/l (INRA, 1988) and it is not dependent on dietary Cu content (Paragon, 1998). Concentrations of copper in milk of experimental animals widely varied among different treatments (from 0.356mg/kg in treatment C to 1.379 mg/kg in treatment D) as well as among animals in each treatment. Differences in Cu content in milk of animals among various treatments are not statistically significant (P=0.186). Cu content in milk of animals of each treatment were above known literature values (INRA,1988;Grace,1989;Anderson,1992).

According to many authors normal Zn content in cow's milk ranges from 3 to 5 mg/kg of milk. There exists a strong correlation between Zn content in milk and in ration (p a r a g o n, 1998). High Zn content in ration increases Zn content in milk, but further increasing Zn in diet has little effect. Because of almost same concentrations of Zn in experimental rations, differences in Zn content in milk among different treatments were not statistically significant (P=0.461). Zn contents in milk of sampled animals (from 3,250 mg/kg in treatment C to 4,110 mg/kg in treatment A) corresponded with published values reported by INRA (1988),Grace(1989),Anderson(1992)and Underwood (1981).

Balance of Zn and Cu

Average daily balance of investigated trace elements age given in the following table.

Table 5. Zn and Cu balance

	Rations					
	A	B	C	D	S.E.*	P**
Cu-mg	3.00±0.61 ^{b}	4.96±1.09 ^{b}	5.47±0.65^{b}	10.06±1.14^{a}	0.87	0.003
%	1.61	2.78	3.21	4.74		
Zn-mg	43.34±21.07	26.44±7.80	16.90±4.84	40.91±14.77	6.64	0.531
%	4.22	2.90	2.06	3.86		

a,b Means in the same rows with different letters in their superscripts differ ~< *0,05)*

Most of feedstuffs, especially concentrates, contain high concentrations of Cu, despite the fact that Cu deficiency in animal nutrition is very often due to different interactions between Cu and other minerals. As a consequence, this demonstrates very low levels of Cu retention. Generally, absorption of Cu is not more than 5-10% in adult animals, while young animals' may absorb 15-30% of Cu McDowell, 1992). The average Cu balance of all experimental rations were positive and ranged from 3.00 mg (ration A) to 10.06 mg (ration D).

The mean value of Cu balance in ration D is higher P=0.003) compared to other rations. Copper deficiency is a serious problem for grazing ruminants in many countries of the world. This is due both to low concentrations of Cu in forage as well as to elevated amounts of Mo and S, which interfere with copper utilization (Baker, 1995). This fact explains a higher balance of Cu in ration D because of the lower concentration of forage in total dry matter of that ration.

The average Zn balance of all experimental rations were positive and ranged from 16~90 mg (ration C) to 43.34 mg (ration A) with strong variations among animals (S.E. = 6,64) so differences among different treatments were not statistically significant (P=0.531). The most important factor affecting absorption is Zn content of the diet. With high Zn in diet, there is a reduction in the percentage absorbed (sometimes to less than 10%). Dairy cattle compensated for low Zn in diets by increasing absorption, a decrease in milk Zn, and a decline in excretion of Zn in feces (McDowel1, 1992). This fact explains high levels of Zn in experimental rations and relatively low balance of Zn of each treatments.

CONCLUSIONS

On the basis of investigation the following conclusions can be drawn:

1. Cu and Zn content in investigated feedstuffs ranged according to published values. Cu and Zn content in forage as well as in sugar beet pulp could not satisfy dairy cow's demands. The concentrations of Cu and Zn in other feedstuffs (brewer's grain, sunflower solvent extracted with hulls and concentrate mixture) were above recommendations for dairy cows.
2. Zn and Cu content in the examined rations were above recommendations (NRC, 1984; INRA, 1988; ARC, 1980 and Grace, 1989) but below toxic levels.
3. Although there exists a correlation between Cu and Zn content in milk and its content in ration, the mean values of their content in milk of tested animals were not statistically significant.
4. Copper and Zinc balance were counted as a difference between their amount in rations and their amount in feces, milk and urine.

The average Cu balance of all experimental rations were positive and ranged from 3.00 mg (ration A) to 10.06 mg (ration D). The mean value of Cu balance in ration D is higher (P=0.003) compared to other rations.

The average Zn balances of all experimental rations were positive and ranged from 16.90 mg (ration C) to mg (ration A) with strong variations among animals (S.E.= 6.64) so differences among different treatments were not statistically significant.

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