EFFECT OF TWO DIFFERENT SOURCES OF ZINC SUPPLEMENTATION ON PRODUCTIVE PERFORMANCE OF FRIESIAN DAIRY COWS

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SUMMARY

This study was conducted to investigate the effect of zinc sulfate and zinc methionine supplementation on the digestion coefficients, nutritive value, ruminal and some blood parameters, milk yield and milk composition of Friesian dairy cows. Animals were fed according to the NRC feed allowances for dairy cattle (1989). Fifteen Friesian dairy cows were divided into three groups (five animal each). Animal were fed on the following rations: Control group fed concentrate feed mixture (CFM), berseem (Trifolium alexandrinum) hay and rice straw without zinc supplementation. The 1st tested group was fed control ration + 40mg zinc sulfate /kg dry matter intake (DMI) and the 2nd tested group was fed control ration +40mg zinc methionine /kg DMI. All groups were fed for a period from the expected calving date to 182 days of their lactation season. Results indicated that the addition of zinc improved the nutrient digestibilities and feeding values as TDN and DCP. Also, zinc supplements tended to reduce ammonia-N and somatic cell counts but increased TVFA's, improved feed efficiency and milk yield. Moreover, zinc supplementation improved serum total protein and globulin, but reduced the concentration of both albumin and urea in blood serum.

Keywords: Friesian cows, zinc methionine, feed intake, digestibility, ruminal and blood parameters, milk yield, somatic cell counts

INTRODUCTION

Use of amino acid complex minerals as mineral supplement compared with inorganic sources is known to be more available. Metal proteinates are produced by chelation of a soluble metal salt with amino acids and /or partially hydrolyzed protein. Trace elements have been traditionally added to ruminant rations in the different forms such as zinc sulfate or zinc methionine. Zinc is known to be essential for the function and structure of several enzymes as dehydrogenases, peptidases, phosphatases, a transphosphorylase, transcarbamylase, carboxpeptidase. Zinc is also essential component of both DNA, RNA polymereses (Miles and Henry, 1999). It is also vital for a variety of hormonal activities including growth hormone, glucagon, insulin, as well as sex hormones. However, in recent years, there has been considerable interest in feeding ruminants amino-trace minerals to increase the bioavailability of the mineral above that of the soluble inorganic sources (Henry, 1995; Rojas *et al.*, 1995 and Luo *et al.*, 1996). The metal complex or chelate is stable in the digestive tract and is thus protected from forming complexes with other dietary components which could inhibit the absorption (Formigoni *et al.*, 1993; Spears, 1996 and Cao *et al.*, 2000). In the animal, trace minerals occur and function as organic complexes, or chelates, and not as free inorganic ions Spears (1996). Apparent absorption of Zn is similar for ruminants supplemented either with organic or inorganic Zn (Spears, 1989). Zn proteinate (znprot) improved performance and carcass characteristics in finishing steers (Spears and Kegley, 2002). However, Zn could be used to reduce ruminal degradability of feed protein and to promote greater quantities of ruminal escape protein (Britton and Lopfenstein, 1986). Many studies have shown improved growth, milk yield, reproductive performance and /or immune response in ruminants fed diets containing organic trace minerals (Spears, 1996, Socha and Johanson, 1998 and Gunter *et al.*, 1999). Milk yield was found to increase when Zn in the form of Zn-Met or Zn-Lys was added to the diets of lactating cows (Kincaid, 1993). High levels of supplemental of zinc methionine were also shown to have a positive influence on ewe milk production and lamb weaning weights (Hatfield *et al.*, 1995) Other studies on lambs have shown that zinc sulfate or zinc oxide were similar in bioavailability (Kegley and Spear, 1992 and Sandoval *et al.*, 1997b).

The objective of this study was to compare the effect of Zinc sulfate and Zinc methionine supplemented to the ration of Friesian dairy cows on nutrient digestibilities, nutritive values, some ruminal and blood parameters, milk yield and its composition.

MATERIAL AND METHODS

This study was conducted in Karada, Animal Production Research Station belonging to the Animal Production Research Institute, Agricultural Research Centre, Egypt. Fifteen Friesian cows were divided into three similar groups (five animals each) body weight, milk yield and age. Cows were fed on one of the following ration: 1- Control group was fed concentrate feed mixture (CFM), berseem (*Trifolium alexandrinum*) hay and rice straw without zinc supplementation. 2- The 1^{st} tested group was fed control ration supplemented with 40mg zinc sulfate /kgDMI . 3- The 2^{nd} tested group was fed control ration supplemented with 40mg zinc methionine /kgDMI according to the feed allowances of NRC (1989). Feed additives (Zinc methionine with content of 80.5% methionine hydroxy analogue and 15.10% Zinc sulfate)and were mixed manually with some ground amounts of CFM.. Feeding experiments was started three month before the expected calving date and continued up to 182 days of lactation. Each group was given (during prepartum) a maintenance ration plus productive requirements which can cover and equivalent to produce 2kg milk production with 4% fat daily. After parturition cows were fed according to NRC feed allowances for dairy cattle (1989). Rations were offered twice daily at 8 a.m. and 4 p.m. Water was offered freely. Cows were milked twice daily at 7.0 a.m. and 4.0 p.m. using milking machine. Daily milk yield was recorded individually and composite and representative samples of milk (morning and evening samples) were mixed by ratio of 1% weight of milk and analyzed biweekly for fat, lactose , protein , total solids , solids not fat and somatic cells counts using Milkoscan apparatus. Energy of milk was calculated using the formula of Overmann and Sanmann (1926) where energy of milk (Kcal) = 115.3 (2.51+ fat%). Actual milk yield was converted into 4% fat corrected milk (FCM) using the formula given by Gaines (1923) as 4% FCM = 0.4milk yield +15.0 fat yield. Three digestibility trials were carried out at the middle of the feeding trials using three cows from each group to determine the nutrient digestibilities and nutritive value of the experimental rations using Acid insoluble ash (AIA) technique according to Van Keulen and Young (1977). Fecal samples were collected from the rectum daily for four successive days from each animal. Chemical composition of the feeds and feces samples were analyzed according to A.O.A.C. (1995) procedures. Rumen liquor samples were collected by stomach tube at three times (just before morning feeding, 3.00 and 6.00 hrs after feeding). Samples were strained in four folds of cheese cloth. Ruminal pH was determined immediately using a digital pH meter. Ammonia-N was determined according to the modified semi-micro kijeldehl digestion method A.O.A.C. (1995). Total volatile fatty acids (TVFA's) was determined according to Eadie *et al.* (1967). Blood samples were taken from each animal at the end of the collection period of each trial before feeding from jugular vein and allowed to flow into acid washed heparinzied tubes. Blood samples were centrifuged immediately at 4000 rpm for 20 minuets.Blood plasma was used for determination of total protein, albumin, urea, and zinc content. Total protein was determined according to the Weichselboum (1946). Albumin was determined colorimetrically according to the Drupt (1974). Urea was determined according to Fawcett and Scott (1960). Zinc was determined according to Makino *et al.* (1982).

The Economic efficiency (%) was calculated as a percentage of price of daily milk yield (L.E) to average daily feed cost (L.E.)

The obtained data were statistically analyzed by general linear, model using ANOVA procedures of SAS (1985). The significant differences between treatments were tested using Duncan Multiple Range test (Duncan, 1955).

RESULTS AND DISCUSSIONS

Chemical composition of feedstuffs

Data of table (1) showed that the chemical composition of feedstuffs were within the normal values published by A.P.R.I. (1997).

Table 1. Chemical analysis of the feed stuffs and calculated chemical composition of the tested rations (DM basis%)

Item	DM	OM	CP	EE	CF	Ash	NFE
*CFM	90.40	90.22	16.20	2.99	13.10	9.78	57.93
Berseem hay (3[ed] cut)	90.39	86.84	14.82	2.39	28.75	13.16	40.88
Rice straw	92.18	85.00	3.10	1.76	36.12	15.00	44.02
Calculated experimental ration							
Ration 1 (control)	91.02	87.92	11.40	2.47	23.36	12.08	50.69
Ration 2	91.01	87.97	11.51	2.49	23.13	12.03	50.84
Ration 3	90.89	88.34	12.43	2.57	21.51	11.66	51.83

*Concentrate feed mixture contained : 42% undecorticated cotton seed meal, 10% wheat bran,30%yellow corn, 10% rice bran ,5% molasses, 2% limestone and 1%common salt.

Nutrient digestibilities and feeding values:

Data presented in table (2) indicate that the addition of zinc sulfate or zinc methionine significantly ($P<0.05$) increased the digestibilities of OM, CP and CF compared to control group, while there were no significant differences in case of

DM, EE and NFE digestibilities in all rations. Also, no significant differences were found between the two Zn sources. However, higher digestibility values were found with rations contained zinc supplementation. The higher apparent digestibility coefficient with zinc supplemented rations may be due to the improvement of their digestibility and absorption. These results are in line with those obtained by Shakweer *et al.* (2005) who found that the apparent digestibility of DM, OM, CP and CF were significantly improved with added different levels of zinc methionine in the ration of Friesian dairy cows . Mousa and EL-Sheikh, (2004) found that the apparent digestibility of DM,OM,CP,CF;EE and NFE were slightly increased by different levels of zinc sulfate supplementation to the ration of lactating buffaloes. However, Dinn *et al.* (1998) reported that the apparent digestibility of CF was increased significantly with addition of protected amino acids than those of unprotected.

Table .2. Nutrient digestibilities and feeding values of the experimental rations

Item	Control	Experimental rations		
		Control+ 40mg/kgDMI Zinc sulfate	Control+ 40mg/kgDMI Zinc methionine	SE
Digestibility (%)				
DM	67.25	68.78	69.07	.0.57
OM	68.47^{b}	70.77^{a}	71.24^{a}	0.86
CP	64.11^{b}	71.52^{a}	71.70^{a}	2.50
CF	58.28^{b}	61.76^{a}	62.19^{a}	1.24
EE	68.36	70.42	70.61	0.72
NFE	77.19	78.04	78.12	0.30
Nutritive values (%)				
TDN	63.84^{b}	66.12^{a}	66.85^{a}	0.91
DCP	7.31^{c}	8.23^{b}	8.91^{a}	0.46

a,b,c : means in the same row followed by different superscripts are significantly ($P<0.05$) different

Nutritive values as TDN and DCP were ($P<0.05$) increased by the addition of either zinc sulfate or zinc methionine supplementation compared to control group (Table 2) but the highest value of DCP was observed for cows fed Zinc methionine. The improved TDN and DCP for tested rations might be due to higher digestibility values of the nutrients of zinc supplemented groups. . These results are in accordance with Shakweer *et al.* (2005) and Mousa and EL-Sheikh (2004) who found that the TDN and DCP were significantly increased by the added different levels of zinc methionine or zinc sulfate.

Rumen parameters:

Data presented in table (3) showed that the pH value decreased after the 0.00 time of feeding, meanwhile ammonia-N and TVFA's increased and reached a peak value at 3hrs post feeding and decreased then after to the lowest value at 6hrs post feeding .The pH values were not significantly affected by zinc supplementation. However, pH value at 6.0 hr after feeding tended to decrease when zinc sulfate was added compared with zinc methionine or the control group. These results are in harmony with those found by Dinn *et al.* (1998) and Robison *et al.* (2002) . On the other hand, Bharadwaj *et al.* (1999) and Demeterova *et al.* (2002) reported that there was a slight decrease in rumen pH value when protected amino acid supplemented to the basal diet of lactating buffaloes but Shakweer *et al.* (2005), Shakweer and EL-Nahas (2005) and Shakweer, *et al.* (2006) found a slight increase in rumen pH values with addition of different levels of zinc methionine in the ration of Friesian dairy cows.

Ammonia-N concentration in ruminal fluid decreased with zinc sulfate or zinc methionine compared with that of the control group. These results are in line with those obtained by Shakweer *et al.* (2005), Shakweer and EL-Nahas and (2005) Shakweer, *et al.* (2006) who found that the ammonia-N in ruminal fluid was decreased by adding different levels of zinc methionine in the ration of Friesian dairy cows. Arelovich *et al.* (2000) found that added zinc or zinc plus Mn inhibited NH_3 accumulation in the rumen , which may be due to decrease of ureolysis or increase of ammonia utilization by ruminal microbes..

The total VFA's increased with either zinc sulfate or zinc methionine supplement (Table 3). This increase in TVFA's may be due to the increase of the digestibility of organic matter. These results are in accordance with the findings of Shakweer, *et al.* (2005) , Shakweer and EL-Nahas (2005) and Shakweer, *et al.* (2006) who found that the VFA's increased with all different levels of zinc methionine supplementation compared with that of the control group .Arelovich *et al.* (2000) reported that the increased proportion of propionate in ruminal VFA leads to an increased energetic efficiency of ruminal fermentation which might explain the consistent benefits obtained from addition of chelated zinc

Table 3. The effect of zinc sulfate or zinc methionine supplement on ruminal pH, NH_3, TVFA's values

Parameters	Time	Control	Experimental rations		
			Control+ 40mg/kgDMI Zinc sulfate	Control+40mg/kgDMI Zinc methionine	SE
pH	0	7.34	7.09	7.06	0.09
	3	6.53	6.22	6.13	0.12
	6	6.77	6.09	6.48	0.20
Ammonia_N (mg/100ml RL)	0	21.53	20.08	18.06	1.01
	3	33.63^{a}	31.95^{ab}	29.14^{b}	1.31
	6	28.72^{a}	27.86^{a}	22.47^{b}	1.96
TVFA's (meq/100ml RL)	0	6.44^{b}	6.48^{b}	6.98^{a}	0.17
	3	8.13^{b}	8.64^{ab}	9.42^{a}	0.38
	6	6.33^{b}	6.56^{a}	6.70^{a}	0.11

a,b,c : means in the same row followed by different superscripts are significantly ($P<0.05$) different.

Blood parameters:

Concentration of plasma total protein , globulin and zinc increased , while concentrations of plasma albumin and urea decreased due to the Zn supplements (Table 4). Similar findings, were obtained by Shakweer *et al.* (2005), Shakweer and EL-Nahas and (2005) Shakweer *et al.* (2006) who found normal concentration of total protein, globulin and zinc with different level of zinc methionine supplementation. Mousa and EL-Sheikh (2004) indicated that addition of 80 and 120mg zinc sulfate improved total protein and globulin , while it decreased albumin and urea concentrations in blood serum of lactating buffaloes . Moreover, Reid *et al.* (1987) and Spears and Kegleg (2002) found an increase (P<0.05) in serum zinc concentration of lambs fed alfalfa supplemented with varying zinc levels .

Table 4. Effect of zinc sulfate or zinc methionine supplement on some blood parameters

Items	Control	Experimental rations		
		Control+ 40mg/kgDMI Zinc sulfate	Control+ 40mg/kgDMI Zinc methionine	SE
Total protein g/dl	7.28^{b}	7.77^{a}	8.06^{a}	0.23
Albumin g/dl	4.43^{a}	4.22^{a}	4.00^{a}	0.12
Globulin g/dl	2.85^{b}	3.55^{ab}	4.06^{a}	0.25
Urea mg/dl	38.38^{a}	34.06^{ab}	33.18^{b}	1.61
Zinc mg/dl	0.70^{b}	0.73^{b}	0.79^{a}	0.03

a,b,c: means in the same row followed by different superscripts are significantly (P<0.05) different

Milk yield and composition:

Zinc sulfate or zinc methionine supplementation significantly increased the actual and 4% fat corrected milk yield of dairy Friesian cows compared to that of the zinc sulfate and also control group. Milk composition was not affected by the tested ration (Table 5). Similar results were reported by Miller *et al.* (1989), Kellogg and Lane (1996), Compbell *et al.* (1999), Shakweer *et al.* (2005) , Shakweer and EL-Nahas and (2005) and Shakweer *et al.* (2006), that cow milk components were not affected by zinc supplementation. The addition of zinc sulfate or zinc methionine to rations appeared to (P<0.05) decrease somatic cell counts compared with that of the control group (Table 5). These results are in accordance with that Uchida *et al.* (2001), Shakweer, *et al.* (2005), Shakweer and EL-Nahas (2005) and Shakweer *et al.* (2006) who found decreased somatic cell counts with added zinc to ration of dairy cows. Milk energy was increased with added zinc sulfate or zinc methionine compared to that of the control group. However, Zali *et al.* (2008) found that milk yield and body weight were not affected by adding 15 or 30 mg/kg of diet to ewes diet.

Feed intake and feed efficiency:

Data of table (6) show that feed intake as(DM,TDN and DCP) was increased with zinc sulfate or zinc methionine supplementation compared to control group. Feed efficiency was higher with added zinc methionine /kg DMI than that of zinc sulfate and control group. This might be attributed mainly to the better nutrient digestibility and feeding values as shown by Arelovich *et al.* (2000). Similar findings were also obtained by Mousa and EL-Sheikh (2004) who indicated a slight improvement of feed efficiency when 40mg zinc sulfate was added to lactating buffaloes ration. Shakweer *et al.* (2005) found that feed efficiency and milk yield were increased with different levels of zinc methionine (40,80 and 120mg /kgDMI) supplementation.

Table 5. Average actual daily milk yield , 4%fat corrected milk yield and milk composition of lactating Friesian cows fed rations supplemented with zinc sulfate or zinc methionine

Items	Control	Experimental rations		SE
		Control+ 40mg/kgDMI Zinc sulfate	Control+ 40mg/kgDMI Zinc methionine	
Actual milk yield, kg/day	11.9^{c}	12.7^{b}	14.7^{a}	0.83
4% fat correct milk yield, kg/day	11.31^{c}	12.30^{b}	14.60^{a}	0.98
Milk composition (%)				
Fat	3.70	3.78	3.97	0.08
Protein	2.65	2.67	2.73	0.02
Lactose	4.29	4.33	4.37	0.02
Solids non fat	7.64	7.53	7.70	0.05
Total solids	10.80	11.27	11.47	0.20
Milk energy (Kcal/kg milk)	716	725.2	747.1	9.23
Somatic cells counts /ml	484^{a}	383^{b}	350.67^{b}	40.20

a,b,c: means in the same row followed by different superscripts are significantly ($P<0.05$) different

Table 6. Feed intake and feed efficiency of lactating cows fed rations supplemented with zinc sulfate or zinc methionine

Items	Control	Experimental rations		SE
		Control+ 40mg/kgDMI Zinc sulfate	Control+ 40mg/kgDMI Zinc methionine	
Daily feed intake (as fed),kg				
CFM	7.4	7.95	8.85	-
Berseem hay (3rd cut)	2	2	2	-
Rice straw	5	5	4	-
Daily feed intake (as DM),kg				
CFM	6.69	6.98	7.97	-
Berseem hay	1.81	1.81	1.81	-
Rice straw	4.61	4.61	3.69	-
Total daily intake, (kg,head)				
DM	13.11	13.40	13.47	-
TDN	8.37	8.86	9.00	-
DCP	0.96	1.10	1.20	-
Daily 4% FCM yield , kg	11.31^{c}	12.30^{b}	14.60^{a}	0.98
Feed efficiency :				
4% FCM /kg DM	0.86^{c}	0.92^{b}	1.08^{a}	0.07
4% FCM /kg TDN	1.35^{c}	1.39^{b}	1.62^{a}	0.08
4% FCM /kg DCP	11.77^{b}	11.18^{c}	12.17^{a}	0.29

a,b,c: means in the same row followed by different superscripts are significantly ($P<0.05$) different

Economic efficiency:

Feed cost per kg milk produced (L.E.) decreased with added zinc methionine compared to the control group (table 7). While economic cash return (L.E./h/d) was more pronounced with ration contained zinc methionine than other rations. Also economic efficiency was improved with added zinc methionine or zinc sulfate, respectively compared to control group.

Table 7. Economic efficiency of lactating cows fed rations supplemented with zinc sulfate or zinc methionine

Items	Control	Experimental rations	
		Control+ 40mg/kgDMI Zinc sulfate	Control+ 40mg/kgDMI Zinc methionine
Daily feed intake (as fed), kg			
CFM	7.4	7.95	8.85
Berseem hay (3rd cut)	2	2	2
Rice straw	5	5	4
Total feed intake, kg/h/d	14.4	14.95	14.85
Zinc supplement , g/h/d	0.00	1.64	4.01
Total daily feed cost (L.E.)/h/d	13.94	14.84	16.28
Actual milk yield kg/h/d	11.9	12.70	14.70
Feed cost/kgmilk(L.E.)	1:17	1.17	1.11
Price of daily milk yield (L.E.)	23.8.	25.40	29..40
Economical return (L.E/h/d)	9.86	10.54	12.96
Economic efficiency (%)	1.71	1.71	1.79

Calculation on based of the following price in Egyptian pound (L.E.) per ton at 2007, concentrate feed mixture (CFM)= 1600 L.E./ton, Berseem hay=700 L.E./ton, Rice straw=140 L.E./ton, zinc sulfate=30 L.E./kg, zinc methuionine =40 L.E./kg, the price of one kg of milk was 2 L.E .

CONLUSION

From the obtained results, It could be concluded that adding zinc methionine or zinc sulfate to the rations of dairy cows improved nutrients digestibility , feeding values , milk yield and its composition and decreased somatic cell counts compared to unsupplemented ration.

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تأثير إضافة مصدرين مختلفين من الزنك على الأداء الإنتاجي لأبقار الفريزيان الحلابة

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أجري هذا البحث بهدف مقارنة تأثير إضافة مصدرين من الزنك على معاملات الهضم والقيمة الغذائية ومحصول اللبن وبعض مقاييس الكرش والدم، استخدم 15 بقرة حلابة وتمت التغذية على علائق مضاف إليها كبريتات الزنك أوالزنك المثيونين حتى اليوم 182 من موسم الحليب.

قسمت الأبقار إلى ثلاثة مجاميع على النحو التالي 1- مجموعة للكنترول غذيت على علف مركز + دريس برسيم + قش أرز بدون إضافة الزنك 2- مجموعة مختبرة غذيت على عليقة الكنترول + 40ملجم زنك (كبريتات الزنك) /كجم مادة جافة مأكولة 3- مجموعة مختبرة غذيت على عليقة الكنترول + 40 ملجم زنك مثيونين /كجم مادة جافة مأكولة . وكانت النتائج كالآتي:

أدت إضافة الزنك المعدني (كبريتات الزنك) أوالزنك المرتبط بالمثيونين إلى تحسن في معاملات الهضم والقيمة الغذائية للعليقة المأكولة وكذلك محصول اللبن مقارنة بمجموعة الكنترول ، بينما أدت إضافة زنك المثيونين إلى العليقة إلى زيادة محصول اللبن اليومى وكذلك العائد الاقتصادي مقارنة باضافة الزنك المعدنى (كبريتات الزنك) ومجموعة الكنترول. أما بالنسبة لمقاييس الكرش فقد أدت إضافة الزنك المعدني والزنك المرتبط مع المثيونين إلى انخفاض تركيز امونيا الكرش وزيادة تركيز الاحماض الدهنية . اما بالنسبة لمقاييس الدم أدت الى ارتفاع تركيز بروتين الدم والجلوبيولين بينما انخفض تركيز الألبومين ويوريا الدم بينما أدت إضافة كبريتات الزنك و زنك المثيونين إلى انخفاض أعداد الخلايا الجسدية فى لبن الأبقار الفريزيان مقارنة بمجموعة الكنترول.

وتوصى الدراسة : بأن إضافة كبريتات الزنك أو زنك المثيونين بمستوى40 ملجم/كجم مادة جافة ماكولة/اليوم أدى الى تحسن فى المركبات المهضومة وقيمتها الغذائية وكذلك ناتج اللبن اليومى. إلاّ أن إضافة زنك مثيونين إلى علائق الأبقار الحلابة كان أفضل من إضافة كبريتات الزنك من حيث الكفاءة الإنتاجية والإقتصادية.