Assiut Vet. Med. J. Vol. 40 No. 80, January 1999.

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ZINC SULFATE SUPPLEMENTATION TO RUMINANT RATIONS AND ITS EFFECTS ON DIGESTIBILITY IN LAMBS; GROWTH, RECTAL TEMPERATURE AND SOME BLOOD CONSTITUENTS IN BUFFALO CALVES UNDER HEAT STRESS

(With 7 Tables and 3 Figures)

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(Received at 5/11/1998)

تأثير إضافة كبريتات الزنك إلى علائق المجترات على الهضم فى الأغنام ودرجة حرارة الجسم والنمو وبعض مكونات الدم فى عجول الجاموس تحت ظروف الضغط الحرارى

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تم إجراء تجربتين مختلفتين لدراسة تأثير إضافة كبريتات الزنك إلى علائق المجترات على الهضم، النمو، درجة حرارة الجسم وأيضا بعض مكونات الدم تحت الظروف الضاغطة لإرتفاع درجة الحرارة. استخدم فى التجربة الأولى ستة ذكور من الأغنام الصعيدى لدراسة تأثير إضافة كبريتات الزنك على الهضم. أما فى التجربة الثانية التى استمرت ١٨٠ يوما تحت الظروف المناخية الحارة فقد استخدم ثلاثة مجموعات من العجول الجاموس كل مجموعة تحتوى على (٣ ذكور ، ٣ إناث) لدراسة تأثير إضافة كبريتات الزنك على كل من النمو، درجة حرارة الجسم وأيضا الميتابولزم فى عجول الجاموس. كانت العلائق المختبرة عبارة عن عليقة الكونترول (الضابطة) أو مضاف إليها ٥٠ مليجرام (مجموعة ١) أو ١٠٠ مليجرام (مجموعة ٢) لكل كيلو جرام عليقة من كبريتات الزنك. وقد كانت الحيوانات موجودة داخل الإسطبل طوال فترة التجربة. أوضحت النتائج أن معاملات هضم المركبات الغذائية والقيم الغذائية قد تحسنت نتيجة لإضافة كبريتات الزنك. فقد زاد معنويا هضم كلا من المادة العضوية، البروتين الخام والكربوهيدرات الغير ذائبة عند مستوى معنوية ١ % فى كل من الأغنام المعاملة بينما زاد هضم الألياف معنويا عند مستوى ١ % فقط فى المجموعة الثانية مقارنة بالمجموعة المغذاة على العليقةالمقارنة (الكونترول). كما أدى إضافة كبريتات الزنك خلال ٦ شهور (مدة تجربة النمو) إلى زيادة معدل النمو اليومى فى المجموعة الأولى عند مستوى معنوية (١ %) والمجموعة الثانية عند مستوى معنوية (٥%) عن عجول الكونترول (المجموعة الضابطة). علاوة على ذلك فقد انخفض متوسط درجة

حرارة الجسم معنويا عند مستوى ١ % ، ٥ % فى كل من المجموعة الأولى والثانية على التوالى مقارنة بالمجموعة الكونترول مما يدل على أن زيادة معدل النمو اليومى تتوافق مع انخفاض درجة حرارة الجسم. أدت التغذية اليومية على كبريتات الزنك إلى حدوث زيادة معنوية (١ %) فى كل من تركيز الزنك فى سيرم الدم ، فيتامين A ، بيتا كاروتين ، البروتين الكلى وأيضا الجلوبيولين الكلى بينما ارتفع سكر الدم وأنزيم اسبرتات ترانس فيريز عند مستوى معنوية (٥ %). كذلك أدت المعاملة بكبريتات الزنك إلى زيادة غير معنوية فى نسب كل من الألبيومين ، الكوليسترول الكلى وثلاثى جليسريدات أو ايضا انزيم الانين ترانس فيريز بينما انخفضت نسبة كل من اليوريا نيتروجين والكالسيوم عند مستوى معنوية ١ % بينما لم يتأثر مستوى الفسفور العضوى بالتغذية على كبريتات الزنك. هذا ويتضح من النتائج السابقة ان كبريتات الزنك يمكن ان تؤدى إلى تحسن فى معاملات هضم المركبات الغذائية والقيم الغذائية وبعض مكونات سيرم الدم التى لها علاقة بالميتابوليزم فى الحيوانات المختبرة بالاضافة إلى ذلك أدت التغذية على الزنك إلى انخفاض درجة حرارة الجسم مما يمكن القول بأن الزنك عامل منظم لدرجة حرارة الجسم مما يجعل الحيوان أكثر تأقلم تحت أجواء الجو الحار الذى يعانى منه الحيوان معظم شهور السنة خاصة فى صعيد مصر.

SUMMARY

Two different studies were carried out to test the effect of zinc sulfate addition to ruminant rations on digestibility, growth performance, rectal temperature and some blood constituents under stress of hot climatic conditions. Six Saidi rams were used at the first study to test the effect of zinc sulfate on digestibility. In the second study, which lasted for 180 days during hot climatic conditions, three groups of buffalo calves (3 males and 3 females) with 129 ± 3.77 kg average initial body weight were used to investigate the influence of dietary zinc sulfate supplementation on performance, rectal temperature, and metabolic status of buffalo calves. The experimental animals were fed a basal diet (control) or supplemented with 50 mg (T1) or 100 mg per kg diet (T2) $ZnSO_4.7H_2O$. Animals were housed indoor during hot summer conditions. The results indicated that the nutrient digestibilities and feeding values were improved due to addition of zinc sulfate. The digestibilities of OM, CP and NFE increased ($P<0.01$) in treated lambs while CF increased ($P<0.01$) only in T2 group compared with those fed control ration. Zinc supplementation during the 6-month growth trial increased ADG in T1 ($P<0.01$) and T2 ($P<0.05$) than the control calves. Meanwhile, mean rectal temperature decreased in both T1 ($p<0.01$) and T2 ($P<0.05$) calves compared to the controls indicating that the highest daily gain coinciding with the lowest rectal temperature. Dietary zinc sulfate resulted in an increase ($P<0.01$) in zinc concentration in blood serum, Vit.A, beta-carotene, total protein and total globulin while serum glucose and SAST elevated significantly ($P<0.05$). Numerical increase in serum albumin, total cholesterol, triglycerides and SALT was noticed while concentrations of BUN and calcium decreased significantly ($P<0.01$). Inorganic phosphorus was not affected by zinc supplementation. Dietary zinc sulfate may improve growth performance, nutrient digestibilities, feeding values and selected blood serum metabolities in tested animals. In addition, fed zinc may regulate thermal mechanism of animals to adapt under heat stress, by reducing their rectal temperature, especially in upper Egypt conditions.

Key words: *Zinc sulfate, Digestibility (lambs), growth, rectal temperature, metabolic Profiles, buffaloes calves.*

INTRODUCTION

In Egypt buffaloes are considered the main dairy animal in addition to their significant contribution to the annual beef production which ranged from 42 to 45% (El-Ashry et al., 1994). During the last two decades, various feed additives and subcutaneous implants have been used to stimulate growth and to improve feed efficiency of different ruminant species except buffaloes ((Brandt et al., 1991 and Zinn and Borques, 1993). Zinc (Zn) is a very important element because it acts as a component and an activator for over 200 metalloenzymes and hormones (Riodran and Vallee, 1976) and it is essential for multitude of body functions. Kirchgassner and Heindle, (1993) indicated that, feeding zinc to ruminants generally improved growth performance. These improvement could be due to the improvement of acid base balance (Hahn and Baker, 1988), DNA and nutrients metabolism (Banerjee, 1988), the activities of digestive enzymes (Izhboldina, 1994) and/or the efficiency of dietary protein utilization (Froetschel et al., 1990). Also, zinc supplementation to the ration caused significant increases in carotene, vitamin A and gamma globulin in blood serum (Bednarek et al., 1991), improved fertility (Apgar, 1971 and Fitzgerald et al., 1986) and activated immunity protection (Gross et al., 1979 and Bires et al., 1993).

Because the changes in blood chemistry associated with feeding zinc sulfate to buffaloes under hot climate has not been sufficiently studied, these trials were carried out to determine the influence of zinc sulfate addition to ruminant rations on nutrient digestibility of lambs, performance, rectal temperature and changes in serum metabolites of buffalo calves rations (which has been reported to be lack in zinc as reported by Attia et al., 1987).

MATERIALS and METHODS

Two different studies, digestibility study using Saidi lambs and growth study using buffalo calves, were undertaken during the hot summer conditions from May to October, 1997. Animals were chosen at almost the same age and fed a basal diet (control) or a basal diet supplemented with 50 & 100 mg/Kg diet zinc sulfate for the experimental groups.

Diets:

To meet the growth requirements of growing buffalo calves as stated by Ghoneim (1958), concentrate mixture (corn, decorticated cottonseed meal and wheat bran) was offered to the animals at a rate of 2.5% BW and roughage (rice straw) was fed ad lib. Limestone and mineralized salts were given to cover the requirements as shown in Table (1).

Table 1: Feed ingredients and chemical composition of experimental diets on DM basis.

Item	Amount			
Feed ingredients, (as fed basis) %				
Corn	35			
Decorticated cottonseed	25			
Wheat bran	37			
Limestone	2			
Mineralized salt	1			
	Experimental diet (mg Zinc sulfate/kg diet)			
	Control (0)	T1 (5O)	T2 (100)	rice straw
Analysis (as DM basis) %				
Organic matter (OM)	90.70	91.80	91.70	95.30
Crude protein (CP)	13.00	12.50	13.30	2.90
Ether extract (EE)	1.80	2.80	3.10	1.40
Crude fiber (CF)	8.40	8.80	7.80	31.00
N-free extract (NFE)	67.50	67.70	67.50	8.70
Ash	9.30	8.20	8.30	16.00
Zinc (mg) •	41.10	59.18	77.18	**

- Zinc sulfate contains 37% zinc.
- ** Zinc not determined.

To the other two diets, zinc sulfate was added to the basal diet at two levels (50 and 100 mg/kg diet, in T1 and T2, respectively). Before mixing the tested diets, the calculated amount of zinc sulfate was hand mixed with the corn portion then the last was mixed with the rest of the ingredients. All ingredients were mechanically mixed in a hummer mill mixture

Digestion trials:

Six clinically healthy Saidi rams were used in three digestibility trials (2 rams/each) to determine the nutrient digestibilities of different rations. Each digestion trial lasted for 21 days of which two weeks were considered as a preliminary period followed by 7 days as a collection period. During the collection period total fecal output was collected and 10% of it were sampled daily. Samples were oven dried at 65 C^{O} for 48 h, then ground and stored for chemical analysis.

Growth trial:

In a growth trial lasted for 24 weeks, a number of eighteen, 8 months old, buffalo calves (9 males and 9 females) with an average initial body weight of 129.5±3.77 kg were used. Animals were divided according to their body weight into three equal groups (3 males and 3 females each). Experimental animals were adapted to the control diet one month before starting the trial. All groups were housed indoor (semi-open stable) and kept under the same environmental and managerial conditions.

All groups were weighed monthly before morning feeding to adjust the requirement of concentrate mixture. Concentrate mixture was offered (2.5% of BW) twice daily in equal portions at 9.00 a.m. and 3.00 p.m. while rice straw was offered ad lib. Clean drinking water was freely available along the experiment. In all groups rectal temperature was recorded biweekly at 12.00 hrs. Air temperature (AT,C^{o}) and Relative humidity (RH,%) were recorded simultaneously with recording rectal temperature. Average AT and RH were 32.6 ± 2.97 and 57.2 ± 1.34, respectively during the experimental period (180 day).

Sampling and chemical analysis.

Blood samples (10 ml), from each animal, were collected bimonthly by Jugular venipuncture into dry non heparinized glass tube and allowed to clot at room temperature for 30 minutes. Blood sera were separated by centrifugation at 3000 rpm. for 15 minutes, decanted into plastic vials and stored at - 20 C^{o} until the time of assay. Ash, ether extract (EE) and crude fiber (CF) contents of feed and feces were determined as explained by the AOAC (199O). Total N content (CP) of feed and feces were determined using Kjeldahl procedure (AOAC, 1990). Nitrogen free extracts (NFE) were obtained by differences.

Metabolic profile elements including glucose, total protein, albumin, total cholesterol, triglycerides, serum aspartic aminotransferase (AST), serum alanin amino treanferase (ALT), urea N, calcium and inorganic phosphorus were determined using the calorimetric assay Kits supplied by Sclavo (Italy). Serum vitamin A (Vit A) and beta carotene were estimated according to the methods of Carr and Price (1962). Concentration of zinc in blood serum was assayed using atomic absorption spectrophotometer.

Statistical Analysis.

Collected data were statistically analyzed using the General Linear Model procedure of SAS software (1987). Treatment effects were also examined by one-way ANOVA (Steel and Torrie, 1980). The statistical model for the study was:

$Yij = U + Ti = Eij$ Where

Yij= The value of the dependent variable for the ith treatment.

U = Common mean.

Ti= Treatment effect i=1-3

Eij= Random error

Significant differences of means were tested using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS and DISCUSSION

Nutrient digestibilities

Results in Table 2 indicated that addition of zinc sulfate to the control diet at levels of 50 and 100 mg/kg diet improved the nutrient digestibilities and feeding values of the given diets (with different responses and levels of significance). In this respect, the digestibilities of OM, CP and NFE increased in T1 and T2 ($P<0.01$) groups compared with that of the control one. Zinc sulfate supplementation increased significantly the digestibility of CF ($P<0.05$) only in T2 group. On the other hand, zinc sulfate supplementation did not affect the digestibility of EE. These results cleared that the digestive ability of lambs increased by elevating the level of zinc supplementation. Such observations agree well with those of Froetshel et al., (1990) and Ade-El-Rahim et al.,(1995)

Table 2: Influence of dietary supplementation of zinc sulfate on digestibility, nutritive values of diet and nitrogen utilization of Saidi lambs.

Item	**Treatments**			
	Control	**T1**	**T2**	**MSE**
Apparent digestibility				
OM	75.50^{b}	77.07^{a}	78.97^{a}	0.59
CP	61.50^{b}	63.90^{a}	65.70^{a}	1.53
EE	69.80	69.30	68.70	2.76
CF	39.20^{b}	40.30^{b}	48.30^{a}	1.70
NFE	82.90^{b}	84.60^{a}	85.60^{a}	0.32
Nutritive value (DM basis %)				
SV	67.10^{b}	69.80^{ab}	72.0^{a}	1.58
DE*	3.09	3.22	3.30	0.05
TDE	70.20^{c}	73.10^{ab}	75.00^{a}	1.02
DCP	8.0	8.0	8.70	0.23

MSE: Mean square error.
* Digestible energy (Kcal/kg feed DM) calculated as 1 kg TDN = 4.4 Mcal/kg (NRC/1985).
^{a,b,c} Means with different superscripts are different at ($P<0.01$)

While they did not agree with that reported by Tsyupko et al., (1990) in simmental bull calves. The improvement in the nutritive value of the given diet expressed either as starch value (SV) or total digestible energy (TDE) as shown in Table (2) was a result to the improvement of nutrients digestibility due to zinc supplementation. Increasing the digestive ability of lambs by elevation the level of zinc sulfate supplementation to 50 mg/kg diet may be attributed to increasing the activity of carbohydrates, fats and protein enzymes such as amylase, lipase, trypsinogen, chymotrypsinogen and some peptidase, since these enzymes are known to be zinc-dependent enzymes (Lu and Combs, 1988 and Banerjee, 1988).

On the other hand, Chhabra et al., (1987) did not find any significant differences in digestibility of organic nutrients between control and groups given different amounts of zinc in the diet.

Body weight and average daily gain.

An analysis of the overall experimental period (24 wk) indicated that body weight increased gradually during the trial (Fig. 1). At the end of the experimental period, average body weight of T1 group was significantly ($P<0.01$) higher than that of control group. Final body weight was higher by about 13.9% ($P<0.01$) and 6.5% in T1 and T2 treated-calves, respectively than the control. Average daily gain (ADG) were influenced significantly ($P<0.01$) by the treatments as shown in Table (3) and Figure (2). Attia et al., (1987) found, in male buffalo calves 6-9 months old for 90 days, that 1 gram zinc supplied daily increased weight gain and they attributed this improvement to the lack of zinc content that usually occur in Egyptian feedstuffs.

The response of buffalo calves to zinc sulfate addition may be due to one or more of the following factors: 1) The new level is adequate to increase the activity of zinc metalloenzymes such as RNA and DNA ploymerases and thymidine kinase (Underwood, 1981). These enzymes are responsible for the growth and development of skeleton and synthesis of body protein (Fernandez et al., 1976 and Freeman, 1983). 2) Addition of zinc sulfate to the control diet increased the available zinc to meet the requirement because feed ingredients of the control diet, "wheat bran, cottonseeds meal and corn," are rich in phytic acid content (Clarke et al., 1997 and Barker and Halpin, 1988) which bind with zinc content forming unavailable zinc-phytase complex.

Table 3: Influence of dietary supplementation with different levels of zinc on growth performance of buffalo calves

Item	Supplemental zn sulfate level (mg/kg diet) Control (0)	T1 (50)	T2 (100)	MSE
Initial live weight (Kg)	131.2	128.7	128.7	3.77
Final live weight (Kg)	235.2^{b}	267.8^{a}	250.4^{ab}	4.27
Average weight gain (Kg)	104^{c}	139.1^{a}	121.7^{b}	3.68
Daily weight gain (gm)	577.8^{c}	772.8^{a}	676.1^{b}	17.70
Growth rate %	44.22^{c}	51.94^{b}	48.60^{bc}	1.75
% change due to zinc		33.7	17.0	

MSE: Mean square error.
Means within row differ ($P<0.01$) when superscripts differ.

3) Zinc supplementation reduced ruminal protein degradation, increased propionate concentration and ruminal protozoa numbers (Froetschel et al., 1990) and/or 4) Improved of both nitrogen and energy metabolism (Stake et al., 1973) which is accompanied with an increase in

somatotropin hormones and insulin like growth factor (Kirchgensser and Heindle, 1993).

Low rectal temperature in T1($P < 0.01$) and T2 ($P<0.05$) groups (Fig. 3) may partly explain the improvement in daily gain and body weight of treated calves compared with the control ones. Chirase et al., (1991) showed that there was a corresponding increase in daily DMI and BW with the decline of rectal temperature of steers fed zinc supplementation.

Rectal temperature:

Figure (3) shows a decrease in rectal temperature recorded in T1 ($p<0.01$) and T2 ($P <0.05$) as compared to the control group, which is difficult to explain. Similar finding was reported by Chirase et al., (1991) who showed that steers fed control diet had higher ($P<0.10$) rectal temperature than steers fed zinc supplementation. In this field, low temperature inhibits the peripheral thermal receptors to transmit supperssive nerve impulses to the appetite center in the hypothalamus causing the increase in average daily gain (Habeeb et al., 1992). This was supported by high average daily gain obtained in treated calves in the present study (Table 3). Then feed zinc may regulate thermal mechanism of animals to be adapted to heat stress by reducing their rectal temperature to the normal levels.

Blood metabolites

Zinc concentration

Results in Table (4) show that,as expected, addition of zinc sulfate to the control diet increased zinc concentration of blood serum of the treated calves. These results indicate that addition of zinc sulfate may be increases the available zinc for absorption (Abdel- Rahim et al., 1995). Similar results were obtained by Kegley and Spear, (1994).

Vitamin A and Beta- carotene concentrations

Table (4) shows the effect of zinc sulfate addition on blood serum vit.A and Beta-carotene concentrations. The positive relation and complementary role between Zn and vitamin A might be attributed, as reported by El-Masry and Yousef (1998), to the following factors: 1) Zinc is necessary to activate some enzymes related to vitamin A metabolism such as alcohol dehydrogenase in the liver which is involves in the oxidation of retinol, vitamin A aldehyde in the intermediary conversion of carotene (Berzin, 1988). 2) The interaction between zinc and vitamin A might be accomplished at the level of abosrption and transformation of carotene in the intestinal mucosa (Georgivskii et al., 1991). and/or 3) The stimulatory effect of vitamin A on zinc absorption biologically analogous to that of vitamin D on calcium absorption (Berzin, 1988).

Table 4: Zinc content (mg/dl), vitamin A (Ug%), beta-carotin (Ug%), Calcium and inorganic phosphorus (mg/dl) in blood serum of buffalo calves supplemented with zinc sulfate

.Constituents	Treatments			
	Control	T1	T2	MSE
Zinc	83.65^{c}	92.63^{b}	99.94^{a}	2.05
Vitamin A	37.78^{c}	45.76^{b}	52.41^{a}	2.68
Beta- carotene	49.28^{c}	58.67^{b}	70.84^{a}	3.21
Calcium	10.82a	9.04b	9.34ab	0.51
Phosphorus	5.46	4.94	5.06	0.29

MSE: Mean square error.
a,b,c
Means in the same row with different Superscripts differ (P<0.01)

Serum calcium and inorganic phosphorus:

Average serum calcium concentrations were lower in T1 (P<0.01) and T2 than the control fed buffalo calves (Table 4), during the experimental period, probably due to a decrease in absorption from the gut or a decrease in the sorption of Ca from tissues (Chirase et al, 1991). Low rectal temperature in treated zinc calves (Fig.3) enhances calcium retention (Kamal and Johnson, 1977) which may explain the low level of calcium in treated calves. These results cleared that the availability of Ca was improved by addition of zinc sulfate to the diet at the level of 50 mg/kg and tended to decrease when supplemental zinc sulfate levels increased to 100 mg/kg (Table 4). The availability of inorganic phosphorus was not affected significantly by the dietary zinc level.

Serum glucose.

The overall mean of serum glucose concentration was elevated (P<0.05) in T1 calves and tended to be numerically higher in T2 than control (Table 5). This may be in part related to the increase in concentrations of insulin (Herbein et al., 1985) and thyroxine (El-Masry, 1987), which are correlated closely to the increase in energy metabolism. Moreover, the increase in production of propionate and valerate (Froetschel et al., 1990), may provide up to 70% of the exogenous glucose precursors in ruminants (Baldwin and Smith, 1979) and increased hepatic capacity for gluconeogenesis (Bergman, 1983), would also be related to increase of serum glucose in treated Zn calves.

Table 5: The influence of dietary zinc sulfate on some blood constituents in buffalo calves.

Constituent	Treatments			
	Control	T1	T2	MSE
Glucose,mg/dl	56.74^{d}	66.42^{c}	59.42^{d}	3.27
Total protein,g/dl	6.27^{b}	7.73^{a}	7.70^{a}	0.25
Albumin (A),g/dl	3.29	3.42	3.49	0.10
T.globulin (G),g/dl	2.99^{b}	4.31^{a}	4.21^{a}	0.23
BUN (mg/dl)	27.82a	20.36b	22.15b	1.56
T.cholesterol,mg/dl	64.09	75.70	68.80	4.69
Triglycerides,mg/dl	37.06	42.26	40.94	3.24

MSE: Mean square error. a,b ($P<0.01$) & c,d ($P<0.05$)

Serum total protein, albumin and globulin

Zinc supplementation increased the overall mean of serum total protein ($P<0.01$) and total globulin ($P<0.01$) in treated calves (Table 5). Serum

Serum total protein increased by about 23% and 18% while total globulin elevated by about 44% and 40% in T1 and T2 treated calves, respectively. The significant increase ($P<0.01$) in serum total protein seems to be due to increased protein synthesis as a result of the elevation of anabolic hormone secretion (El-Masry and Habeeb, 1989) and the decrease in the catabolic hormones such as glucocorticoid and catecholamine (Alvarez and Johnson, 1973) which were associated to the decrease in rectal temperature in zinc treated calves (Fig.3). Moreover, The increase in serum protein may also be due to the increase in feed nitrogen (protein intake) of zinc treated calves which increased amino acids available for absorption and metabolism (Baillet et al., 1997). In other words, the further increase in serum total protein with zinc supplementation may be attributed to the role of zinc in activation of some enzymes (Freeman, 1983) that are responsible for utilization of amino acids for protein synthesis.

The increase in serum total globulin in zinc treated calves might be a reflection of the rise in serum total protein (El-Masry and Yousef, 1998). Similarly, Bednarek et al., (1991) found significant increase in gamma globulin in calves fed diet supplemented with zinc. Bires et al., (1992) found in lactating cows that zinc treated group had higher blood immunoglobulin, albumin and total protein than those in untreated one.

Serum urea nitrogen

During different experimental periods, serum urea nitrogen concentration was significantly lower (P<0.01) in zinc treated calves than in controls (Table 5). A lower serum urea nitrogen concentration of zinc treated calves suggests a great utilization of amino acids for protein synthesis which supported by the highest (P<0.01) live body gain recorded in T1 treated calves. Madson (1983) explained the reduction of BUN in zinc fed calves on the bases that zinc increases the efficiency of nitrogen retention by reducing gluconeogenesis from amino acids. This is because most urea is synthesized in the liver from ammoina which is either formed from protein catabolism or absorbed from the gastrointestinal tract (Duncan and Prassa, 1986). Similar decrease of serum urea nitrogen concentration was found in rabbits treated with dietary Zn (Abd El-Rahim et al., 1995).

Serum total cholesterol and triglycerides

Values of serum total cholesterol and triglycerides concentrations tended to be higher in zinc treated buffalo calves (Table 5). Such result of increasing total cholesterol may be due to the increase in acetate concentration which is primary precursor for the synthesis of total cholesterol (Habeeb et al., 1992). In addition, low rectal temperature of treated calves, as compared with untreated ones, accompanied with decrease in progesterone (El-Shafie et al., 1983) and glucocorticoid hormone levels (Thompson, 1973) may be another factor causing the increase in blood serum cholesterol.

In this field, the increase in triglycerides concentration in tested groups could be due to increased glucose availability in treated calves (Table 5). Glucose is essential for triglycerides synthesis because it forms alpha glycerophosphate which is specific precursor of glycerol which fatty acids are esterified for triglycerides formation (Bergman, 1983). In general, the increase in serum levels of both glucose and triglycerides indicate that zinc treated calves were in better condition compared with control calves under heat stress conditions.

Serum aspartic aminotransferase(AST) & alanine aminotransferase (ALT).

Zinc supplementation increased serum AST (P<0.01) concentration (Table 6) in T1 group, however serum ALT concentration was slightly higher in zinc treated calves than that of control. The increase of serum AST concentration may be related to increased body weight due to protein synthesis process (More et al., 1981). In addition, increased metabolism and/or growth performance of zinc treated buffalo

Table 6: Serum Enzymes concentrations (U/l) in buffalo calves fed 0,50, and 100 mg zinc sulfhate/kg of diet

Item	Treatments			
	Control	T1	T2	MSE
SAST	34.58[b]	38.27[a]	36.53[b]	0.72
SALT	14.40	16.23	15.10	0.52

MSE: Mean square error. a,b (P<0.05)
AST: Aspartic aminotransferase, ALT: Alanine aminotransferase

calves may be considered as a response to increased ALT concentration of calves supplemented with zinc as reported by Davidson, (1994) who reported that the function of ALT enzymes is the transfer of amino group from amino acid to synthesise another one and play an important role in gluconeogenesis. Furthermore, an increase of ALT concentration is a response to the increased need for gluconeogenesis.

Economical evaluation

Economical studies showed that the income per Kg gain at the end of the experiment was significantly higher by 154 % and 90 % in both T1 and T2, respectively than those fed control diet (Table 7).

Table 7: Economical evaluation of Zinc sulfate addition

Item	**Treatments**		
	Control	**T1**	**T2**
Growth rate (kg)	0.578	0.773	0.676
Average daily feed intake (Kg)			
Concentrate (Kg)	4.6	5.0	4.7
Roughage (Kg)	3.0	3.0	3.0
Nutritional cost (LE) :			
Concentrate	2.06	2.23	2.10
Roughage	0.15	0.15	0.15
Zinc sulfate	0.00	0.5	0.10
Total nutritional costs	2.21	2.43	2.35
Total costs*	2.95	3.24	3.13
Price of daily gain LE)	3.32	4.44	3.89
Profits	0.37	1.20	0.76
Profits/Kg gain (PT)	64.0	155.3	121.4

* The assumption was nutritional cost is 75% of the total cost.
Feed costs/Ton (L.E): Corn =500, DSCM = 525, Wb= 375, L.S= 50, Mineralzedsalt= 80, Roughage= 50. Kg of life weight= 5.75 (L.E)

These results could be due to better feed efficiency which led to higher average daily gain and consequently the final body weight in Zn treated calves (Table 3).

Implications

This research has confirmed beneficial effects of supplemental zinc for stressed buffalo calves, under hot climatic conditions, as evidenced by improved performance, digestibility, nutritive values, blood constituents and some aspects of immune response, reflected by elevation of total globulin concentration. These aspects are reflected in improvement of growth performance of zinc treated buffalo calves. In addition, fed zinc improved digestibility and nutritive values of treated lambs. Meanwhile, fed zinc may regulate thermal mechanism of animals to adapt under heat stress by reducing their rectal temperature to the normal levels. These points need further investigations.

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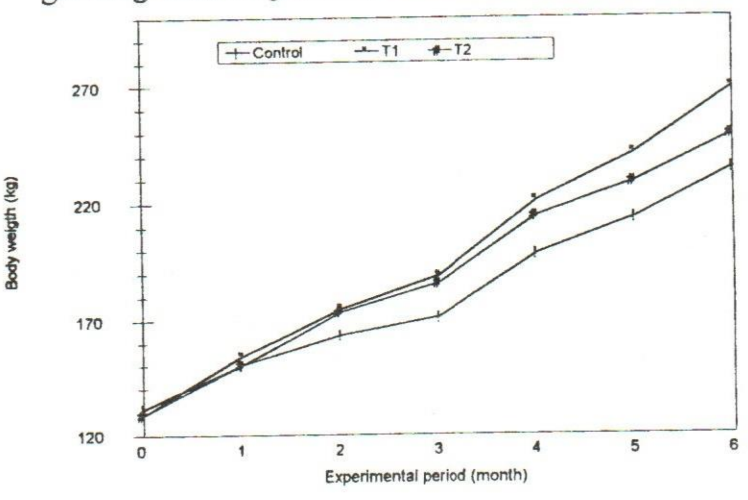

Fig.1 Body weight of buffalo calves supplemented with zinc sulfate

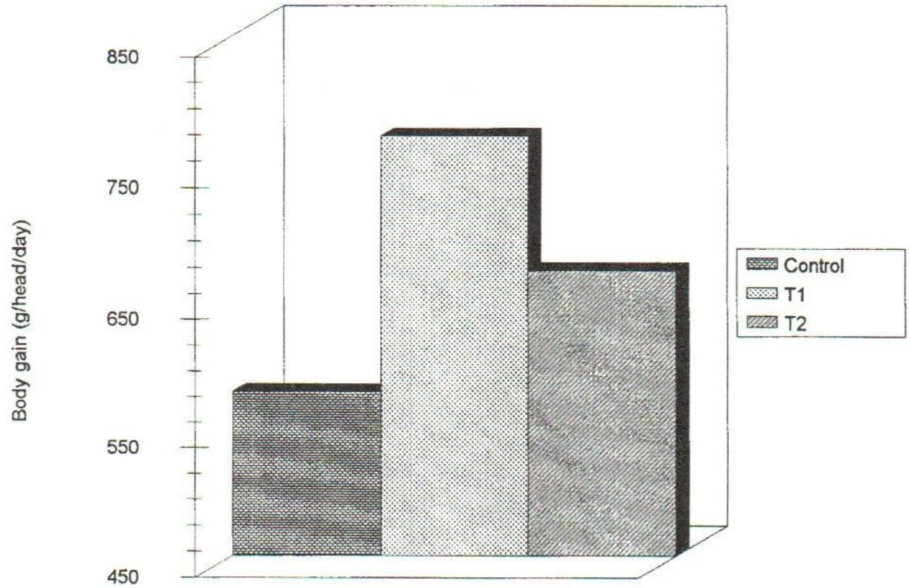

Fig 2.Body gain of buffalo calves supplemented with zinc sulfate

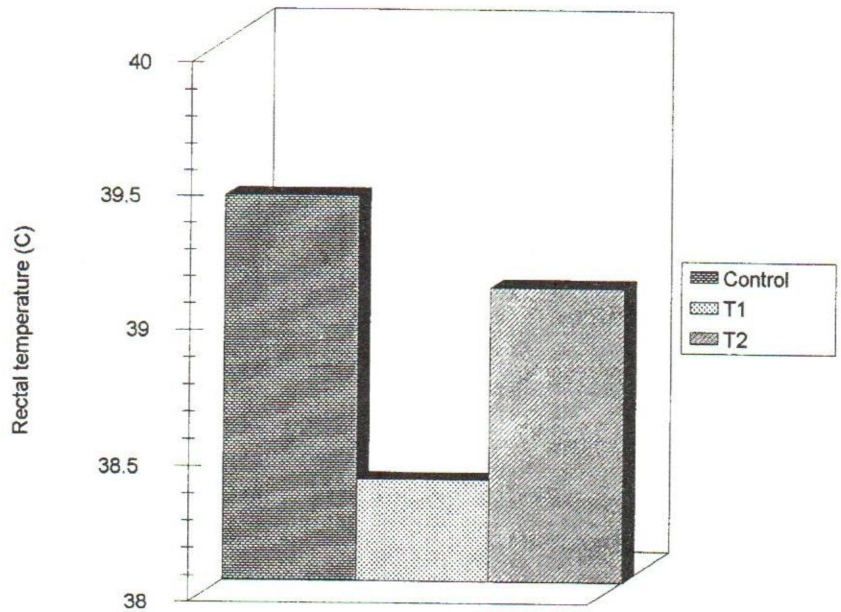

Fig 3. Effect of dietary zinc sulfate on rectal temperature of buffalo calves.