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PRODUCTIVE PEFORMANCE, NUTRIENTS DIGESTIBILITY AND SOME SERUM METABOLIC INDICES AS AFFECTED BY DIEATARY SUPPLEMENTATION OF COPPER AND ZINC IN EGYPTIAN BUFFALO CALVES

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SUMMARY

This study was designed to evaluate the effects of dietary supplementation of copper (Cu) and zinc (Zn) on productive performance, nutrients digestibility and some serum metabolic indices in Egyptian buffalo calves. A total number of 32 calves averaged 278.8 ± 5.40 kg and 18 months old were divided into four equal groups (8 calves / each). Animals were fed on basal diet containing 4.38 mg Cu and 6.30 mg Zn/kg DM (control) supplemented with 10 mg Cu (T1), 30 mg Zn (T2) and 10 mg Cu plus 30 mg Zn (T3) /kg DM for 120 days. Digestibility of DM, NDF and ADF was higher (P<0.05) for calves fed T2 and T3 *vs*. T1 or control. The OM digestibility increased (P<0.05) for calves fed T1, T2 and T3 *vs*. control. Calves fed on T1, T2 and T3 had higher (P<0.05) digestibility of CP and CF than those fed control. Digestibility of CP and CF increased (P<0.05) with feeding T3 ration vs. each of T1 or T2 alone. The digestibility of EE increased (P<0.05) for calves fed T3 vs. those fed T1 or control rations. The digestible crude protein values were greater (P<0.05) with feeding T1, T2 and T3 than control. The total digestible nutrients values increased (P<0.05) for calved fed on T3 when compared to control or T1. Results showed significant (P<0.05) increasing in final body weight for calves fed T2 and T3 *vs*. control or T1. The averages daily gain (ADG) increased (P<0.05) for calves fed T1, T2 and T3 *vs*. control. Also, ADG improved (P<0.05) for calves fed T3 *vs*. those of T1 and T2. In the same time, no significant changes were noticed in feed intakes (rice straw, concentrate feed mixture and total dry matter) among treatments *vs*. control, while digestible crude protein intake increased (P<0.05) for calves fed T1, T2 and T3 *vs*. control. The total digestible nutrients intake increased (P<0.05) with T3 compared to control. Feed conversion was improved (P<0.05) for calves fed T2 and T3 *vs*. control. The T2 and T3 recorded higher (P<0.05) levels of serum total protein, albumin and globulin *vs*. control or T1. Serum globulin levels increased (P<0.05) in calves fed T1 *vs*. control. Feeding T1 decreased (P<0.05) serum cholesterol, but increased (P<0.05) HDL-cholesterol concentrations *vs*. control. The differences in serum glucose and triglycerides concentrations were not significant among calves in T1, T2 and T3 *vs*. control. The present study indicated that dietary supplemental Cu plus Zn showed beneficial additive effects to improve nutritive values, productive performance and blood metabolic indices in buffalo calves.

Keywords: *Buffalo calves, copper and zinc, productive performance, nutrients digestibility and serum metabolic indices.*

INTRODUCTION

Optimal performance, production and metabolic functions require adequate intake of balanced trace elements in livestock. Trace elements as copper (Cu) and zinc (Zn) play an important role in animal's metabolism. Regular supply of both in animal' diets could improve performance, reproduction, immunity, vitamin metabolism and health (Yatoo *et al*., 2013). Cu has functions related to cellular respiration, bone growth, heart function, development of connective tissue, myelination of the spinal cord and erythrocyte production (McDowell, 2003). Also, Cu at physiological concentrations can alter lipid metabolism in ruminants (Engle, 2011). Deficiency of Cu in ruminants could be resulted in metabolic disorders, reduced feed intake, negative effect on feed efficiency and leading to growth retardation (Enjalbert *et al.,* 2006). Zn plays an integral role in regulating a wide variety of body functions including cell division, growth, metabolism, and appetite control. At the same time, Zn deficiency can negatively affect the growth, reproduction and gene expression in ruminants (Underwood and Suttle, 1999). Generally, Cu and Zn are also important for thyroid activity due to their role in synthesis or conversion of thyroid hormones (Abdollahi *et al.,* 2013).

The inter-relationships between Cu and Zn are complex. Supplementation of Zn at high levels might have an antagonistic effect on Cu absorption. Thus, intakes of large amount of Zn can reduce Cu concentrations in plasma and liver of cattle and sheep (Kincaid, 1999). Underwood and Suttle (1999) indicated that an interaction between Cu and Zn assumes practical significance when more Cu is added to ration. Therefore, dietary supplemental levels should be within a 1:3 up to 1:5 ratio of Cu: Zn to maintain optimal status of both micronutrients (Larson, 2005). Supplementation of each micronutrient alone had been shown to improve performance and nutritive values in calves and bulls (Heidarpour *et al*., 2008 and Netto *et al*., 2014). However, limited information is available on the interactive effects of both Cu plus Zn on performance and nutrient digestibility in ruminants.

The present study was designed to investigate the effect of dietary supplemental Cu plus Zn on productive performance, nutrients digestibility, nutritive values and some related serum metabolic indices in buffalo calves.

MATERIALS AND METHODS

Animals:

A total number of 32 Egyptian buffalo calves averaged 278.8 ± 5.40 kg and 18 months old were used to carry out this experiment at the cattle fattening project station belonging to El-Minia governorate-Samalout, El-Minia during January to April 2014.

Experimental design:

The animals were divided into four equal groups (8 calves / each) and fed on concentrate feed mixture (CFM) to cover their nutrients requirements according to NRC (1996). The calculated concentrations of Cu and Zn in the CFM were 4.38 mg/kg DM and 6.3 mg/kg DM, respectively. According to NRC (1996), the requirements of Cu and Zn are 10 mg Cu/kg diet and 30 mg Zn/kg diet. The calves were fed on basal diet (control) supplemented with 10 mg Cu (T1), 30 mg Zn (T2) and 10 mg Cu plus 30 mg Zn /kg DM (T3) for 120 days. The inorganic sources of Cu and Zn were copper sulfate ($CuSO_4.5H_2O$) and zinc sulfate ($ZnSO_4.7H_2O$), respectively. The CFM contained 45 % wheat bran, 25 % yellow corn, 15 % sunflower meal, 5 % soybean meal, 7 % rice bran, 2 % calcium carbonate and 1 % sodium chloride. In this experiment, rice straw (RS) as roughage source was offered *ad libitum*.

Animals were fed individually on the CFM and rice straw offered three times a day. The residual was weighed and the consumed amounts were calculated. Body weights of calves were recorded at the beginning of the experiment and at the end of each month during the experimental period. Averages daily gain and feed conversion of calves were calculated. Fresh water was available along the experiment. Buffalo calves were subjected to the routinely veterinary vaccination and inspection system.

Sampling and laboratory analysis:

Dietary samples were collected daily in the last week of each month along the experiment period and a composite sample was performed. A portion of the composite sample was dried at 105 ˚C in a forced air oven till constant weight for DM determination. The rest of composite sample was dried at 70 ºC for a constant weight, ground and kept in closely tied jars for laboratory analysis.

Diets were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to AOAC (2003). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Goring and Van Soest (1970). Grab fecal samples were collected before feeding at 7 am and 2 pm for each calfe on days 24 and 27 of each month and mixed together, dried on 70 ºC till constant weight and analyzed for DM, OM, CP, CF, NDF, ADF, EE and ash. Total tract digestibility of DM, OM, CP, CF, NDF, ADF and EE were determined using acid insoluble ash as an internal marker according to Van Keulen and Young (1977). Proximate analysis of CFM, RS and total mixed ration (TMR) are presented in Table (1).

Table (1): Proximate analysis of concentrate feed mixture (CFM), rice straw (RS) and total mixed ration (TMR) fed to buffalo calves on DM basis (%).

Item	CFM*	RS	TMR
DM	89.52	89.50	89.51
OM	90.65	91.28	90.86
CP	16.96	3.03	12.46
EE	3.06	1.79	2.65
CF	12.88	44.86	23.20
NFE	57.75	41.60	52.55
NDF	37.53	94.97	56.08
ADF	15.88	60.34	30.23
Ash	9.35	8.72	9.14

**: Concentrate feed mixture contained 45 % wheat bran, 25 % yellow corn, 15 % sunflower meal, 5 % soybean meal, 7 % rice bran, 2 % calcium carbonate and 1 % sodium chloride.*

Blood sampling and serum measurements:

Monthly in the last week, blood samples were collected from the jugular vein of each animal at 8.00 am before feeding and drinking. Samples were left to clot at room temperature for at least 4 h, then the clots were removed and sera were cleared by centrifugation at 1500×g for 20 min and stored at -20 ºC for later assay. Serum total protein, albumin, and glucose were determined colorimetrically using commercial kits. Serum globulin concentrations were calculated by difference between total protein and albumin concentrations. Serum concentrations of cholesterol, triglycerides and high density lipoprotein (HDL) were analyzed colorimetrically by STAT LAB SZSL60-SPECTRUM, using commercial kits. The analysis was performed at Cairo University Research Park, Faculty of Agriculture, Cairo University.

Statistical analysis:

The data were analyzed by least square means analysis of variance using General Linear Model procedure of the statistical analysis system (SAS, 2000). The model used to analyze the different traits studied for calves was as follows:

$Y_{ij} = \mu + T_i + e_{ij}$.

Where: Yij= ij^{th} observation, μ = y_{ij}, Population mean; Ti = Effect of i^{th} treatments and eij= Random error. Duncan's Multiple Range test was used to detect differences between means of the experimental groups (Duncan, 1955).

RESULTS AND DISCUSSION

Nutrients digestibility and mutative value of diets:

The results presented in Table (2) showed that digestibility of DM, NDF and ADF was higher (P<0.05) for calves fed Z and Cu plus Zn supplemented rations than those fed control or Cu alone. Also, the OM digestibility increased (P<0.05) with feeding Cu, Z and Cu plus Zn supplemented rations *vs.* control. Calves fed Cu, Z and Cu plus Zn supplemented rations had higher (P<0.05) digestibility of CP and CF than those fed control ration. In addition, CP and CF digestibility were higher (P<0.05) with feeding Cu plus Zn-supplemented rations than each of Cu or Zn alone. At the same time, the EE digestibility was increased (P<0.05) for calves fed Cu plus Zn-supplemented ration *vs.* those fed Cu or control rations.

Table (2): Effects of Cu and Zn dietary supplementation on nutrients digestion coefficients and nutritive values of experimental treatments.

Item	Treatments				SEM	Sig.
	Cont.	T1	T2	T3		
Nutrients digestibility (%)						
DM	66.54 ^{b}	67.45 ^{b}	69.76 ^{a}	70.21 ^{a}	0.57	*
OM	67.51 ^{c}	70.68 ^{b}	72.98 ^{a}	73.82 ^{a}	0.53	*
CP	67.76 ^{c}	70.41 ^{b}	70.67 ^{b}	72.56 ^{a}	0.30	*
EE	67.20 ^{b}	67.15 ^{b}	68.74 ^{ab}	69.49 ^{a}	0.48	*
CF	61.84 ^{c}	63.31 ^{b}	63.48 ^{b}	65.20 ^{a}	0.28	*
NDF	48.39 ^{b}	53.16 ^{a}	53.24 ^{a}	53.55 ^{a}	0.017	*
ADF	46.99 ^{b}	47.75 ^{b}	48.18 ^{a}	48.91 ^{a}	0.35	*
Nutritive value (%)						
DCP	8.44 ^{c}	8.77 ^{b}	8.81 ^{b}	9.04 ^{a}	0.05	*
TDN	63.89 ^{c}	64.57 ^{c}	66.25 ^{b}	67.64 ^{a}	0.14	*

a, b and c: Means within the same row having different superscripts significantly different at P<0.05.

**: Significant at P<0.05.*

T1: Cu (10 ppm). *T2: Zn (30 ppm).* *T3: Cu (10 ppm) plus Zn (30 ppm) /kg DM).*

The data of nutritive values in Table (2) showed that the DCP values were greater (P<0.05) with feeding Cu, Z and Cu plus Zn-supplemented rations than control. Also, a significant increase (P<0.05) in TDN values with feeding Z and Cu plus Zn supplemented rations when compared to control or Cu alone.

In the present study, supplemental Cu alone significantly (P<0.05) improved the digestibility of OM, CP and CF and NDF, but, no significant changes were observed in digestibility of DM, EE and ADF (Table 2). These results are, partially, consistent with some reports dealt with the effect of dietary supplemental Cu on nutrients digestibility. For instance, digestibility of OM and CP, but not EE, NDF and ADF, was significantly increased in male lambs fed supplemental Cu at 10 mg Cu/kg DM (Dezfoulian *et al*., 2012). The obtained results are consistent with Zhang *et al*. (2007) who noticed no significant effect on DM, EE and ADF digestibility in goats fed 10 and 20 mg Cu/kg DM. This improvement may be attributed to Cu enhanced ruminal fermentation. Also, similar results were reported in growing and finishing steers (Engle and Spears, 2000). It should be realized that there are several environmental, genetic and dietary factors including Cu concentration in the basal diet and level as well as duration of Cu supplementation, likely contribute to the differences observed between studies on nutrient digestibility response to supplemental Cu (Engle and Spears, 2001). Interactions of Cu with other elements such as Mo, S and Zn as well as overall internal Cu homeostasis may also be implicated (Solaiman *et al.,* 2006).

The presented results indicated that dietary supplemental Zn (30 pmm) improved (P<0.05) all nutrient digestibility (DM, OM, CP, CF, NDF and ADF), except EE digestibility, and the nutritive values of DCP and TDN (Table 2). These findings are in good agreement with similar observation that supplemental Zn had improved all nutrients digestibility, nutritive values (TDN and DCP) and feed efficiency in buffalo (Zeedan *et al.,* 2009). The results also reinforced by a recent study showed that dietary Zn supplementation at 20 mg of supplemental Zn/kg of DM (Zn sulfate) increased (P < 0.05) digestibility of CP and NDF, with significant improving in ADG as reported in sheep (Mallaki *et al*., 2015). In addition, digestibility of DM, OM, CP and NDF were also reported to be improved with supplemental Zn in dairy goats (Salama *et al*., 2003). The significant improvement in CP and NDF noticed in the present study on buffalo calves and reported by others in sheep (Mallaki *et al*., 2015) and goats (Salama *et al*., 2003), may suggest a positive role for Zn supplementation in fiber digestion. The present results also agree with Garg *et al*. (2008) who found that dietary supplemental Zn at 20 mg/kg of DM improved ADF and cellulose digestibility in lambs. Such improved ADF digestibility was also shown in goats fed 20 mg Zn/kg of DM from Zn sulfate (Jia *et* *al*., 2009). In male crossbred cattle bulls, feeding diet containing 32.5 mg Zn/kg DM was adequate to support normal growth and nutrients digestibility (Mandal *et al*., 2007).

The significant effect of dietary supplemental Cu or Zn alone in improving nutrients digestibility as shown in the present study, was significantly (P<0.05) more pronounced in the combined effect of both micronutrients (Table 2). Data showed that dietary supplemental Cu (10 ppm) plus Zn (30 ppm) improved (P<0.05) all nutrients digestibility (DM, OM, CP, CF, EE, NDF and ADF) when compared to control. In this combined treatment, there was an additive effect of Cu plus Zn to increase nutrients digestibility and nutritive values as DCP and TDN for calves than each of Cu or Zn alone.

The additive effect of both micronutrients in nutrients digestibility and growth could be discussed in the light of view that they act as components in numerous enzyme systems associated with carbohydrate and protein metabolism (Larson, 2005). In the same way, Jacob *et al.* (2010) concluded that the potential mechanisms of growth performance promotional effects of Cu and Zn may be referred to their antimicrobial activities in that gut microbial flora are altered to reduce fermentation loss of nutrients and to suppress gut pathogens.

Productive performance:

Calves fed Zn and Cu plus Zn supplemented rations showed a significant (P<0.05) increase in their final body weight (FBW) compared to those fed control or Cu alone (Table 3). Also, there were significantly (P<0.05) increases in average of daily gain (ADG) for Cu, Zn and Cu plus Zn supplemented calves *vs.* control. Also, average ADG improved (P<0.05) for calves fed Cu plus Zn supplemented rations *vs.* those of Cu or Zn alone. In addition, data of feed intake indicated no significant change in rice straw intake (RSI), concentrate feed mixture (CFM) and total dry matter intake (TDMI) due to experimental treatments. Meanwhile, digestible crude protein intake (DCPI) and total digestible nutrients intake (TDNI) were significantly (P<0.05) increased for calves fed on Cu, Zn and Cu plus Zn supplemented calves *vs.* control. Feed conversion (FC) improved (P<0.05) for calves fed Zn and Cu plus Zn supplemented rations compared to control or Cu alone. Feed conversion of digestible crude protein (FC-DCP) and TDN (FC-TDN) increased (P<0.05) for calves fed Zn and Cu plus Zn supplemented rations compared to control.

Table (3): Effects of Cu and Zn dietary supplementation on productive performance of buffalo calves.

Parameters	Treatments				SEM	Sig.
	Control	T1	T2	T3		
Body Weight:						
IBW (kg)	282.2	278.2	280.0	274.7	5.40	NS
FBW (kg)	437.50^{b}	444.83^{b}	460.33^{a}	469.67^{a}	4.27	*
ADG (kg/day)	1.29^{c}	1.39^{b}	1.50^{b}	1.63^{a}	0.04	*
Feed Intake (kg/d :						
RS	4.18	4.23	4.13	4.12	0.04	NS
CFM	8.77	8.72	8.72	8.66	0.08	NS
TDM	12.93	12.95	12.85	12.78	0.12	NS
DCP	1.09^{b}	1.13^{a}	1.14^{a}	1.16^{a}	1.39	*
TDN	8.26^{b}	8.36^{ab}	8.51^{ab}	8.64^{a}	0.11	*
Feed Conversion:						
FC (kg feed/kg gain)	10.02^{a}	9.32^{a}	8.57^{b}	7.84^{b}	0.25	*
FC-DCP (kg/gain)	0.84^{a}	0.81^{ab}	0.77^{b}	0.71^{b}	0.02	*
FC-TDN (kg/gain)	6.40^{a}	6.01^{ab}	5.67^{b}	5.30^{b}	0.17	*

a, b and c: Means within the same row having different superscripts significantly different at (P<0.05).

**: Significant at (P<0.05).*

NS: Not significant.

T1: Cu (10 ppm). *T2: Zn (30 ppm).* *T3: Cu (10 ppm) plus Zn (30 ppm) /kg DM).*

The present results indicated that supplemental Cu alone improved ($P<0.05$) the averages of ADG of buffalo calves could be related to the increase ($P<0.05$) in their CP digestibility, DCPI and nutritive value of DCP (Table 2). Also, the tendency of Cu to improve TDNI, FCR, FC-DCP and FC-TDN may be interacted in the positive effect of supplemental Cu on ADG. Similar effects of supplemental Cu on ADG were detected in dairy calves (Heiderpour *et al*., 2008), bulls (Netto *et al*., 2014) and male lambs (Hosienpour *et al*., 2014). In young Holstein bulls, supplemental Cu (30 mg/kg DM) improved their growth performance and decreases the prevalence of lameness (Fagari-Nobijari *et al.*, 2013). In contrast, Datta *et al.* (2007) showed no significant effect of Cu supplementation on performance of goat kids or in steers and heifers (Felix *et al*., 2012).

In the present study, supplemental Zn alone had beneficial effect to improve productive performance such as FBW, ADG, FCR, DCPI, FC-DCP and FC-TDN of buffalo calves (Table, 3). These results are compatible with a previous report showed significant improvement in ADG and FC efficiency in growing buffalo calves fed Zn at 70 ppm (Jadhav *et al*., 2008). In the same way, a significant increase in ADG and improvement in FCR has been reviewed with dietary supplemental Zn in beef cattle (Larson, 2005) and in sheep (Jafarpour *et al.,* 2015). In the present study, the significant improvement in the previous parameters due to positive effect on attained nutrients digestibility and nutritive values of DCP and TDN for calves fed Zn supplemented-rations. Such beneficial effects of dietary supplemental Zn could be mediated enhanced metabolic processes and many enzymes systems, which are concern with the utilization and metabolism of feed nutrients that require Zn for proper functioning as an activator (McDowell, 2003). Supplemental Zn had improved all nutrients digestibility, nutritive values (TDN and DCP) and feed efficiency in buffalo calves (Zeedan *et al.,* 2009). However, other report showed no improve in ADG or feed efficiency in finishing beef steers with dietary supplemental Zn (Malcolm-Callis *et al*., 2000).As far as the combined effect of Cu and Zn is concerned, the results showed a higher ($P<0.05$) improvement in ADG for calves fed Cu plus Zn-supplemented calves than each of Cu alone or Zn alone (Table, 3). This finding may be revealed an additive effect for supplemental Cu plus Zn to improve performance of these treated calves. This additive effect of supplemental Cu plus Zn in enhancing ADG may be related to their significant effect to increase CP digestibility and nutritive values as shown in digestibility data. To the point, it was detected an improvement in ADG for calves grazing wheat pastures with the addition of both Cu and Zn which surpassed gains of cattle receiving either additional Cu only or Zn only (Larson, 2005). In addition, Zn may play an important role in the interactive combined effect with Cu, since it has a critical role in proteolytic enzyme systems associated with muscle protein turnover in calves (Engle *et al,*. 1998).

The present study illustrated that the differences in feed intakes of RS, CFM and TDM were not significant differ among calves fed Cu, Zn and Cu plus Zn supplemented diets *vs*. control (Table 3). This result is consistent with similar observations in bulls fed Cu at 40 mg/kg DM (Netto *et al.,* 2014); and beef steers fed dietary supplemental Zn (Mandal *et al*., 2007).

Serum metabolic indices:

Data presented in Table (4) showed that calves fed Z and Cu plus Z-supplemented diets had higher ($P<0.05$) values of serum total protein (TP), albumin and globulin concentrations *vs.* control or Cu alone. Such increases could be attributed to a favorable role of Zn, which is required for normal protein synthesis and metabolism. In addition, the significant effect of Zn in improving CP digestibility, DCPI and nutritive value DCP may be contributed to the favorable effect of Zn on serum TP and its fractions. The importance of Zn in the efficiency of utilizing absorbed amino acids in protein synthesis has been evidenced for growing calves (MacDonald, 2000). This response was also noticed in reports with dietary supplemental Zn on buffalo calves (Zeedan *et al.,* 2009) and Friesian calves (Shakweer *et al.,* 2010). Supplemental Zn may increase serum albumin *via* improved nitrogen absorption (Abu El-Ella *et al.,* 2014); and increase globulin concentrations (El-Masry *et al*., 1998). Anyway, the values of serum TP, albumin and globulin, in the present study, were within the normal physiological ranges reported in bovine (Hussein *et al.,* 2013). However, the present results disagree with some studies showed that, inorganic or organic Zn did not affect serum TP, albumin and globulin concentrations in sheep (Hassan *et al*., 2011) and dairy cattle (Sobhanirad and Naserian, 2012). While, calves fed Cu-supplemented ration exhibited higher level of globulin *vs*. control (Table 4). Researches dealt with the effect of supplemental Cu upon blood protein profile are limited.

In the current study, although serum glucose concentrations were not significantly different among calves fed Cu, Zn and Cu plus Zn supplemented rations vs. control (Table 4), their levels were maintained within the normal physiological ranges reviewed in bovine (Hussein *et al*., 2013). The results are in keeping with some studies working on cattle (Sobhanirad and Naserian, 2012) and sheep (Hosienpour *et al*., 2014 and Jafarpour *et al.,* 2015).

Table (4): Effects of Cu and Zn dietary supplementation on some serum metabolites indices of buffalo calves.

Parameters	Treatments				SEM	Sig.
	Control	T1	T2	T3		
Total protein (g/dl)	6.62^{B}	6.90^{B}	7.80^{A}	7.91^{A}	0.47	**
Albumin (g/dl)	3.00^{b}	3.10^{b}	3.72^{a}	3.83^{a}	0.12	*
Globulin (g/dl)	3.62^{c}	3.80^{b}	4.08^{ab}	4.08^{a}	0.09	*
Glucose (mg/dl)	58.2	60.7	62.3	63.0	2.50	NS
Cholesterol (mg/dl)	151.4^{a}	140.4^{b}	154.3^{a}	149.6^{ab}	5.54	*
HDL (mg/dl)	54.3^{b}	108.5^{a}	61.2^{b}	68.05^{b}	4.40	*
Triglycerides (mg/dl)	108.3	109.7	111.5	101.3	7.50	NS

a, b and c :means within the same row having different superscripts significantly different at (P<0.05).

**: Significant at (P<0.05).*

***: Significant at (P<0.01).*

NS: Not significant

HDL: High density lipoprotein

T1: Cu (10 ppm). *T2: Zn (30 ppm).* *T3: Cu (10 ppm) plus Zn (30 ppm) /kg DM).*

Data illustrated in Table (4) showed a decrease (P<0.05) in serum cholesterol concentrations concomitant with an increase in serum HDL with no significant changes in serum triglycerides for calves fed Cu-supplemented ration *vs*. control. The decrease in serum cholesterol concentrations with dietary supplemental Cu was also detected in young Holstein bulls (Fagari-Nobijari *et al.,* 2013). Similar responses of these lipid parameters were also noticed with dietary supplemental Cu in male fattening lambs diet (Hosienpour *et al*., 2014) and finishing steers (Engle *et al.*, 2000). These results may be emphasized that dietary supplemental Cu, at physiological concentrations, can alter plasma lipid metabolism in ruminants (Engle, 2011). The improving of endogenous antioxidant defenses and decreasing the oxidative stress may be implicated in supplemental Cu effect on lipid profile (Galhardi *et al.,* 2005) However, some works showed no significant changes occurred in blood cholesterol with Cu supplementation in goats (Solaiman *et al.,* 2006) and bulls (Netto *et al*., 2014). It was noticeable that supplemental Zn or Cu plus Zn had no significant effect on serum cholesterol, HDL and triglycerides concentrations compared to control. Similar observations were reported in beef steers (Malcolm-Callis *et al.,* 2000), cattle (Sobhanirad and Naserian, 2012).

CONCLUSION

From the present study it can be concluded that the dietary supplementation of Cu (10 ppm) plus Zn (30 ppm), in basal diet containing 4.38 mg Cu and 6.30 mg Zn/kg DM showed beneficial additive effects to improve nutritive value, productive performance, and blood metabolic indices for buffalo calves.

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الأداء الإنتـاجى ، معـاملات الهضـم وبعض المؤشـرات الحيويـة للسيرم المتـأثره بالإمداد الغذائى بعنصرى النحـاس والزنك فى علائق عجول الجاموس المصرى

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صممت هذه الدراسة لتقييم تأثير الإمداد الغذائى بعنصرى النحاس والزنك على الأداء الإنتاجى، معاملات الهضم وبعض المؤشرات الحيوية للسيرم فى عجول الجاموس المصرى. استخدم فى هذه الدراسة عدد إثنان وثلاثون من العجول بمتوسط وزن 278.8 ± 5.40 كجم و 18 شهرا من العمر. تم تقسيم الحيوانات إلى أربعة مجموعات متساوية (8 عجول في كل منها). غذيت الحيوانات على عليقة أساسية تحتوى على 4.38 ملجم نحاس و6.3 ملجم زنك / كجم مادة جافة (كنترول) تم إمدادها بـ 10 ملجم نحاس (T1)، 30 ملجم زنك (T2) و 10 ملجم نحاس + 30 ملجم زنك / كجم مادة جافة (T3) وذلك لمدة 120 يوم . قد زادت معاملات هضم الماده الجافه ، الألياف المستخلصه بالمحاليل المتعادله، الألياف المستخلصه بالمحاليل الحامضيه معنويا (P<0.05) للعجول التي غذيت على المعاملات T2، T3 مقارنه بالمعاملهT1 أو الكنترول. كما حدثت زياده معنويه في معامل هضم الماده العضويه للعجول التي غذيت على المعاملات T1، T2، T3 مقارنه بالمعامله الكنترول. كانت معاملات هضم البروتين والألياف الخام أعلى معنويا (P<0.05) للعجول التي غذيت على المعاملات T1، T2، T3 مقارنه بالمعامله الكنترول. كما زادت معنويا (P<0.05) معاملات هضم البروتين والألياف الخام بالتغذيه على المعامله T3 مقارنه بكلا من المعامله T1، T2 كلا على حده. زاد معنويا (P<0.05) معامل هضم المستخلص الإيثيري للعجول المغذاه على المعامله T1 أو الكنترول. كانت القيمه الغذائيه للبروتين المضموم أعلى معنويا للتغذيه على المعاملات T1، T2، T3 مقارنه بالمعامله الكنترول. كما زادت القيمه الغذائيه (المركبات الكليه المضومه) للعجول المغذاه على المعامله T3 مقارنه بكلا من الكنترول أو T1. وقد أظهرت النتائج زياده معنويه (P<0.05) في وزن الجسم النهائي لعجول المعاملات T2، T3 مقابل الكنترول أو المعامله T1. كان هناك تحسن معنوي (P<0.05) في معدل الزياده اليوميه في الوزن لعجول المعاملات T1، T2، T3 مقارنه بالكنترول. كما حدث تحسن معنوي (P<0.05) في معدل الزياده اليوميه في الوزن لعجول المعامله T3 مقارنه بالعجول التي تغذت على المعاملات T1، T2. لم تلاحظ أي تغيرات معنويه في المأكول من الغذاء (قش الأرز، العلف المركز، الماده الجافه الكليه) فيما بين المعاملات مقارنه بالكنترول بينما كان هناك زياده معنويه (P<0.05) في المأكول من البروتين المهضوم للعجول التي غذيت على المعاملات T1، T2، T3 مقارنه بالكنترول. زاد المأكول من المركبات الكليه المهضومه معنويا (P<0.05) بالتغذيه على المعامله (T3) مقارنه بالكنترول. حدثت زياده معنوية (P<0.05) في معدل التحويل الغذائي لعجول التي غذيت على المعاملات T2، T3 مقارنه بالمعامله T1 أو الكنترول. كما زاد معنويا (P<0.05) معدل التحويل الغذائي لكلا من البروتين المهضوم و المركبات الكليه المهضومه للعجول المغذاه على المعاملات T2، T3 مقارنه بالكنترول. كما سجلت التغذيه على المعاملات T2، T3 أعلى معنويا (P<0.05) في مستويات بروتينات السيرم الكليه ، الألبيومين و الجلوبيولين مقارنه بالكنترول أو المعامله T1. زادت معنويا (P<0.05) مستويات الجلوبيولين في السيرم للعجول المغذاه على المعامله T1 مقارنه بالكنترول. التغذيه على المعامله T1 أدت إلى إنخفاض معنوي (P<0.05) في كولستيرول السيرم بينما زاد معنويا (P<0.05) في كولستيرول الدم من نوع HDL مقارنة بالكنترول. فيما كانت الإختلافات في تركيزات كلا من الجلوكوز، الجلسريدات الكليه غير معنويه بين المعاملات T1، T2، T3 مقارنه بالكنترول.

أظهرت نتائج هذه الدراسه أن الإمداد الغذائي بكلا من عنصري النحاس مع الزنك أدى الى تأثيرات إضافيه مفيده لتحسين الأداء الإنتاجي، معاملات الهضم والقيم الغذائيه مصحوبا بعلامات إيجابيه في مؤشرات الدم الحيويه لعجول الجاموس.