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EFFECT OF ZINC SUPPLEMENTATION ON THE PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING LAMBS FED RATIONS DIFFER IN CRUDE PROTEIN CONTENT

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ABSTRACT

Six mature Farafra wethers (43.6 ±3.6 kg) were divided into two similar groups (three animals in each) and used to evaluate six feeding rations in digestibility trials (14 % CP without Zn supplementation (T1), 20 mg/d Zn supplementation (T2), or 30 mg/d Zn supplementation (T3), and 10 % CP without Zn supplementation (T4), 20 mg/d Zn supplementation (T5) or 30 mg/d Zn supplementation (T6) as $ZnSO_4$). The rations contained 14% CP were higher in the digestibility of CP, N balance and DCP than those contained 10% CP. Zinc supplementation with the 10% CP rations increased significantly the digestibility of CP, EE and DCP. There was no significant effect ($P \geq 0.05$) of different levels of zinc with the two levels of protein on the digestibility of OM, CF, NFE and TDN.

Thirty male Farafra lambs (averaged 22.19 kg body weight and 5 months old) were randomly divided into six feeding groups (5 in each) in a growth trail for 6 months to evaluate the effect of zinc sulphate supplementation on growth performance of growing lambs fed rations differ in crude protein content. There was no significant ($P \geq 0.05$) effect of zinc supplementation or protein level on final body weight gain, daily gain, dry matter intake, and feed conversion at the end of the experiment. But lambs fed rations contained 14% CP with Zn supplementation (T2 and T3) gained more rapidly than lambs fed rations contained 10% CP with Zn supplementation (T5 and T6) during the first 112 d of the experiment, and the opposite was happened during the period from 112 to 180 days of the experiment. Empty body weight, carcass weight, and dressing percentage were not significantly affected with increasing CP or Zn level. Zinc supplementation by 20 or 30mg increased proportions of lean and the opposite was found with fat.

The ration contained 10% CP with 20 mg Zn had the highest economic efficiency (being 2.06) and the lowest was found with 14% CP without Zn (1.69). It could be conclude that Zn supplementation improved digestibility, nutritive values and economic efficiency of growing lambs, especially with feeding 10 %CP ration.

Keywords: Zinc- Dietary protein- Sheep- performance- carcass- metabolism.

INTRODUCTION

Protein is a critical nutrient particularly for young rapidly growing animals. Optimal use of protein is a vital target in any practical feeding system, being protein supplements much more expensive than energy feeds, so wasteful usage of it will increase the cost of production.

Riodran and Vallee (1976) indicated that zinc (Zn) is a very important element because it acts as an activator for up to 200 metalloenzymes and

hormones and it is essential for multitude of body functions. The Zn requirement for lambs is estimated to be supplementing 20-33 mg/kg DM (NRC, 1985). Kirchgessner and Heindle (1993) indicated that feeding zinc to ruminants generally improved growth performance. Moreover, zinc supplementation improved both nitrogen and energy metabolism that are cause an increase in somatotropin hormones and insulin as growth factors (Kirchgensser and Heindle, 1993). Supplementation of zinc increases the activity of zinc metalloenzymes such as RNA and DNA polymerases and thymidine kinase, which are responsible for the growth, development of skeleton and synthesis of body protein (Underwood, 1981and Freeman, 1983). Zinc supplementation increases the availability of zinc to meet animal's requirement, specially if the rations are containing wheat bran, cotton seeds meal or yellow corn which are rich in phytic acid content that bind with zinc forming unavailable zinc- phytate complex. In addition, zinc supplementation reduced ruminal protein degradation, increased propionate concentration and ruminal protozoa numbers (Froetschel *et al.*, 1990). Therefore, the present investigation was conducted to study the effect of zinc supplementation on metabolism and growth performance of growing lambs fed rations differ in CP content.

MATERIALS AND METHODS

Metabolism trial:

Six mature Farafra wethers (43.6 ±3.6 kg) were divided into two similar groups (three animals in each) and used to evaluate six experimental rations. Wethers in the first group was fed rations contained 14 % CP (R1) without Zn supplementation (T1), with 20 mg/d Zn supplementation (T2) or with 30 mg/d Zn supplementation (T3), while the other group was fed rations contained 10 % CP (R2) without Zn supplementation (T4), with 20 mg/d Zn supplementation (T5) or with 30 mg/d Zn supplementation (T6). Zinc was supplemented as $ZnSO_4$. Every digestion trial lasted 28 day, 21 day as a preliminary period and 7 days as a collection period. The concentrate feed mixture (CFM) consisted of corn, soybean meal, limestone and mineral-vitamin premix was mixed with berseem hay by 60: 40%, respectively (Table 1). The wethers were weighed at the beginning of the experiment, and DM intake was restricted at 2 % of initial BW throughout the trial to cover the maintenance requirements. The rations were fed once daily at 0900 and samples represented tenth of the voided feces and excreted urine were taken daily just after collection. Urine samples were stored in tight bottles containing sulfuric acid (1:1) and refrigerated at 4° C for nitrogen determination while, feces samples were dried at 60° C for 24 hours. Samples of dry feces and feeds were ground (1- mm screen) and stored for chemical analysis.

Feeding trial:

This experiment was carried out at Malawi Animal Production Research Station (Elmenia governorate), Agricultural Research Center, Ministry of Agriculture, Egypt. Thirty male Farafra lambs (averaged 22.19 kg body weight and 5 months old) were randomly divided into six feeding groups

(5 animals in each) and fed the previous rations, for 6 months in a growth trial, at 3 % of live body weight. Offered amounts of feed were adjusted biweekly after recording animals' weight. Drinking water was available at all times. Feed intake was daily recorded, meanwhile, daily body weight gain and feed conversion (g feed / g gain) were calculated.

Table(1): Ingredients and proximate analysis (on DM basis) of the experimented rations fed to growing lambs.

	Tested rations	
Items	**14% CP**	**10% CP**
A) Ingredient, %		
Yellow corn	45	56
Soya bean meal	12	1
Berseem hay	40	40
Limestone	2	2
Vitamins& Minerals premix	1	1
B) Proximate analysis, %		
Dry matter (DM)	87.38	87.49
Organic matter (OM)	91.48	92.08
Crude protein (CP)	14.43	9.94
Ether extract (EE)	2.23	2.34
Crude fiber (CF)	12.54	12.38
Nitrogen free extract (NFE)	62.28	67.42
Ash	8.52	7.92
Zn, mg/kg	28.26	25.12

Measurements at slaughter

At the end of the growth trial, 3 lambs from each group were slaughtered. Live body weight (LBW) was recorded before slaughtering. After slaughtering, omental mesenteric fat (OMF), and different components of offals were weighed. The included skin, head, feet, thoracic organs (heart, lungs+ trachea) and viscera (digestive tract, liver and kidney) were weighed. All fractions of digestive tract (reticulo-rumen + omasum, abomasums, and intestine) were weighed with and without digestive contents to deduce digestive contents weight. Its weight was subtracted from BW to obtain empty body weight (EBW). Carcasses were weighed warm (WCW) and the commercial dressing percentage (CDP) was calculated as follow:

DPA (%) = 100 X WCW/ BW or DPB (%) = 100 x WCW/ EBW

Laboratory analysis

The proximate analysis of feeds, feces, and urine were carried out according to the conventional method of A.O.A.C. (1990). Zinc was determined by atomic absorption spectrophotometery (Varian Tecchtron AAL atomic spectrophotometer), (Techtran Pty. Ltd., Melbourne, Australia).

Statistical analysis

Data were statistically analyzed using the general liner model of SAS (1986). Significant differences between means were tested by Multiple rang test (Duncan, 1955).

Yij = m + Ti + eij
Yij = the observation
M = the over mean
Ti = effect of ration (i = 1 to 6)
Eij = the randomized experimental error

RESULTS AND DISCUSSION

The chemical composition of the tested rations represented in Table 1 indicated that the two tested rations were almost similar in their chemical composition except R1 was higher in CP and zinc content than R2 (being 14.43% CP and 28.26 mg Zn/kg DM vs. 9.94% CP and 25.12 mg Zn/kg DM).

Nutritional evaluation:

Data in Table (2) showed that the ration contained 14% CP without Zn (T1) was significantly higher in the digestibility of CP ($P<0.05$) and subsequently the nutritive value as DCP than those contained 10% CP without Zn (T4). This result may be due to the high content of CP in T1. This result agreed with the findings of Willms *et al.* (1991) who found an improvement in CP digestibility by growing lambs when CP level was increased from 6 to 16%.

Table (2):Digestion coefficients, nutritive value and nitrogen balance by Farafra rams fed different levels of zinc and crude protein.

		R1			R2		
Items	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SE**
A) Digestion Coefficients, %							
DM	75.10^{ab}	75.93^{ab}	78.56^{a}	73.52^{b}	75.54^{ab}	76.51^{ab}	4.38
OM	77.80	79.10	80.38	77.02	78.21	79.90	4.06
CP	65.61^{ab}	67.90^{a}	67.11^{a}	54.00^{d}	57.12^{c}	58.65^{bc}	7.70
CF	52.53	56.33	60.68	50.68	55.50	58.58	11.85
EE	82.58^{c}	84.65^{bc}	90.08^{a}	81.90^{c}	84.10^{bc}	88.41^{ab}	5.13
NFE	85.54	86.26	86.89	85.08	85.28	86.65	2.8
B) Nutritive Values, %							
Total digestible nutrients (TDN)	73.47	74.72	76.04	73.32	74.48	76.16	
Digestible crude protein (DCP)	9.47^{a}	9.68^{a}	9.80^{a}	5.37^{c}	5.68^{bc}	5.83^{b}	3.8
C) Nitrogen balance:							
Nitrogen intake, g/h/d.	19.89	19.75	19.70	13.30	13.13	13.64	
Fecal nitrogen, g/h/d.	6.84	6.34	6.48	6.12	5.63	5.64	
Urinary nitrogen, g/h/d.	11.33	11.29	9.61	6.57	6.12	6.76	
Nitrogen balance, g	1.72^{ab}	2.12^{ab}	3.61^{a}	0.61^{b}	1.38^{ab}	1.24^{ab}	0.88

R1= Rations contained 14% CP; T1= R1+ 0 mg Zn T2= R1+ 20 mg Zn /d; T3= R1+ 30 mg Zn/d; R2= Rations contained 10% CP; T4= R2+ 0 mg Zn; T5= R2+ 20 mg Zn/d; T6= R2+ 30 mg Zn/d.

^{a,b,c} Means in the same row with different superscripts are significantly different ($P<0.05$)

Adding Zn by 20mg in T2 or by 30mg in T3 improved the digestibility of all nutrients, nutritive values and nitrogen balance compared with T1. In this respect, the digestibility of DM, CP and EE increased in T3 and T2 compared with that of T1. Zinc supplementation increased the digestibility of CF, but this increase was not significant. The same trend was observed when the corresponding Zn levels were added in T5 and T6 compared with T4. On

the other hand, zinc supplementation did not affect the digestibility of OM and NFE. These results cleared that the digestive ability of rams increased by elevating the level of zinc supplementation. Such results agreed with those of Froetshel *et al.* (1990) and Daghash and Mousa (1999). The improvements in the nutritive value of the given rations (TDN and DCP) as shown in Table (2) were a result of the improvement in nutrients digestibility due to zinc supplementation. Increasing the digestive ability of lambs by elevation the level of zinc sulfate supplementation to 20 or 30 mg/d may be attributed to increase the activity of carbohydrates, fats and protein enzymes such as amylase, lipase, trypsinogen, chymotrypsinogen and some peptidases, since these enzymes are known to be zinc dependent enzymes (Daghash and Mousa, 1999).

Results of nitrogen balance showed an increase with increasing protein and zinc levels. On the other hand, Chhabra *et al.* (1987) reported that Zn level beyond 50 ppm in calves ration could not affect digestibility of different nutrients and nitrogen balance.

Growth performance:

Table 3 presented that there was no significant ($P \geq 0.05$) effect of zinc supplementation or protein level on final live body weight (LBW), average daily gain (ADG), total live body weight gain, daily feed intake and feed conversion of lambs, while lambs fed ration contained 14% CP without Zn supplementation (T1) gain more rapidly (Fig. 1) than lambs fed ration contained 10% CP without Zn supplementation (T4) during the first 112 d being 121.80 and 106.84 g, respectively. Lambs supplemented by 30mg (T3) grew faster than T2 and T1 (being 144.91, 138.07 and 121.80 g, respectively) during the first 112 d (Fig. 1). Lambs in T5 and T6 had higher ADG than those in T4 (being 142.06, 140.29 and 118.09 g, respectively) during the period from 112 to 180 days. Also, lambs in T5 and T6 had higher ADG than those in T2 and T3 (being 142.06, 140.29, 111.91 and 106.47 g, respectively) at the same period (Fig. 1). These results agreed with the findings of Greene *et al.* (1988) and Daghash and Mousa (1999).

The response of growing lambs to zinc sulfate addition may be due to one or more of factors. The first one that the new level is adequate to increase the activity of zinc metalloenzymes such as RNA and DNA polymerases and thymidine kinase, which are responsible for the growth, development of skeleton and synthesis of body protein (Underwood, 1981and Freeman, 1983). The second one that zinc supplementation increases the available zinc to meet animal's requirement especially in rations contain yellow corn and soya bean meal which are rich in phytic acid that bind with zinc forming unavailable zinc- phytate complex (Barker and Halpin, 1988). The third one that zinc supplementation reduces ruminal protein degradation, increases propionate concentration and ruminal protozoa numbers (Froetschel *et al.*, 1990). Moreover, zinc supplementation improves nitrogen metabolism that causes an increase in somatotropin hormones and insulin as growth factors (Kirchgensser and Heindle, 1993).

Table (3):Effect of different levels of zinc and crude protein on nutrient intake, live body weight gain and feed conversion of lambs.

		R1			R2		
Items	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SE**
A) Live body weight:							
Initial live body weight, kg	22.27	22.22	22.24	22.23	21.97	22.22	3.23
Final live body weight, kg	42.97	43.76	44.63	41.99	43.40	43.68	6.17
Total body weight gain, kg	20.70	21.54	22.39	19.76	21.43	21.46	5.14
Daily body weight gain, g	115	120	124	110	119	119	28.66
B) Feed intake:							
Total DMI, g/h/d.	946	912	960	945	911	926	
TDN Intake, g/h/d.	695	681	730	692	678	705	
TDN, kg/ kg $W^{0.75}$	0.050	0.049	0.051	0.053	0.050	0.051	
C) Feed conversion, feed/ gain							
DMI	8.23	7.63	7.71	8.60	7.65	7.76	2.77
TDN	6.04	5.68	5.89	6.30	5.70	5.93	2.05

R1= Rations contained 14% CP T1= R1+ 0 mg Zn T2= R1+ 20 mg/d Zn T3= R1+ 30 mg/d Zn
R2= Rations contained 10% CP T4= R2+ 0 mg Zn T5= R2+ 20 mg/d Zn T6= R2+ 30 mg/d Zn

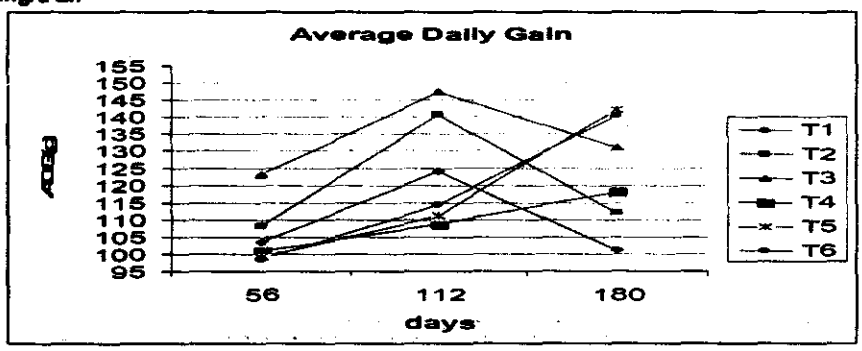

Figure (1): average daily gain of growing lambs fed different levels of zinc and crude protein during 56, 112 and 180 days of the experiment.

Carcass characteristics:

No significant effect was found regarding empty body weight, carcass weight, and dressing percentage due to the increase of the crude protein or zinc level in the ration (Table 4). Lambs of different groups at the same slaughtered weight; showed slight difference of EBW, carcass weight, and dressing percentage. This result agreed with the findings of Atti *et al.* (2004) who found that ration contained crude protein (100, 130 and 160g/kg DM) did not affect empty body weight, carcass weight and dressing percentage in male goat kids. Umunna *et al.* (1980) found that levels of crude protein in steers' rations (11.6, 14.7 and 17.7 %) did not affect carcass weight and dressing percentage. Woolley *et al.* (2005) found that carcass weight and dressing percentage in lambs were not affected by protein level in ration (12.7 and 15.5%). Malcolm-Callis *et al.* (2000) reported that increasing added zinc concentration from 20 to 200 mg/kg DM of ration did not influence hot carcass weight and dressing percentage of beef steers. Berrie *et al.* (1995)

reported no differences in carcass weight and dressing percentage of lambs supplemented with zinc methionine or $ZnSO_4$ at 35 or 70 mg/kg of DM.

Table (4): Slaughter body weight (BW), empty body weight (EBW) and dressing percentages (DP).

		R1			R2		
Items	T1	T2	T3	T4	T5	T6	SE
BW, kg	42.70	44.40	44.20	41.00	42.67	43.83	6.00
EBW, kg	39.01	40.19	40.43	37.83	39.00	39.46	4.36
Carcass W, kg	20.33	21.97	21.79	20.03	21.11	22.05	2.92
DPA, %*	47.64	49.52	49.35	48.85	49.48	50.30	3.25
DPB, %**	52.10	54.66	53.88	52.94	54.14	55.88	4.77

R1= Rations contained 14% CP T1= R1+ 0 mg Zn T2= R1+ 20 mg Zn/d T3= R1+ 30 mg Zn/d

R2= Rations contained 10% CP T4= R2+ 0 mg Zn T5= R2+ 20 mg Zn /d T6= R2+ 30 mg Zn/d

*** Dressing % relative to body weight ** Dressing % relative to empty body weight**

Results in Table (5) showed that weights of 9, 10 and 11 ribs, bone and lean were not affected by protein and zinc levels in rations. All animals had comparable bone weight and proportion. It could be due to that animals were slaughtered at the same weight, and bone is a tissue with early development in all animal species and does not depend on regimen at older ages (Atti *et al.*, 2004). Proportions of fat and lean were affected by protein and zinc level in rations. Lambs of low protein rations had relatively more lean and lower fat ($P<0.05$) than those received high protein level rations. Zinc supplementation by 20 or 30mg increased proportions of lean and decreased proportions of fat. It means that nitrogen was efficiently used from 10% CP ration than in 14% CP ration with Zn supplementation than without Zn supplementation. These findings agreed with Berrie *et al.* (1995), Tegene Negesse *et al.* (2001), Atti *et al.* (2004) in goats and Woolley *et al.* (2005) in lambs. Such a result suggests that 10% CP with 30mg Zn supplementation could be a good dietary nitrogen level for growing lambs.

Economical evaluation:

Based on market prices at the beginning of experiment. The prices were as follow: Whole corn 950; soybean meal 2000; berseem hay 700 (L.E / ton), mineral- vitamin mix; 4.5; and zinc sulphate 22 (L.E./ kg). The selling price of one- kg live body weight was 18 L.E. *Economic efficiency expressed as the ratio between the price of total live weight gain and the price of feed consumed. Tag El-Din *et al.* (1999).

Data of the economical evaluation of feeding growing lambs on the tested rations were summarized in Table (6) and indicated that the ration contained 10% CP with 20 mg Zn/d as Zn SO_4 (T5) had the highest economic efficiency being 2.06, while, the lowest economical efficiency was 1.69 in the ration contained 14% CP without Zn supplementation (T1).

Conclusion

From the previous results, it could be concluded that adding of Zn sulphate to rations contained 14 (28.26 mg Zn/kg DM) or 10% CP (25.12 mg Zn/kg DM) improved digestibility of nutrients, nutritive values, performance and economic efficiency of growing lambs, especially with 10 %CP level.

Table (5):Physical composition of 9, 10 and 11 ribs (sample) cut of the slaughtered lambs.

		R1			R2		
Items	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SE**
Sample W, g	486.10	513.20	528.00	519.33	527.00	554.67	88.00
Sample bone, g	84.33	89.67	92.80	92.67	93.00	96.67	16.00
Bone, %	17.35	17.47	17.58	17.84	17.65	17.43	3.77
Sample Lean, g	285.93	307.10	319.60	317.33	326.67	351.33	80.00
Lean, %	58.82	59.84	60.53	61.10	61.99	63.34	6.26
Sample Fat, g	115.83	116.43	115.60	109.33	107.33	106.67	11.75
Fat, %	23.83^{a}	22.69^{ab}	21.89^{ab}	21.05^{ab}	20.37^{ab}	19.23^{b}	3.77
Lean: Bone, %	3.39	3.42	3.44	3.42	3.51	3.63	1.18
Lean: Fat, %	2.47	2.64	2.76	2.90	3.04	3.29	0.83

R1= Rations contained 14% CP T1= R1+ 0 mg Zn T2= R1+ 20 mg Zn/d T3= R1+ 30 mg Zn/d.

R2= Rations contained 10% CP T4= R2+ 0 mg Zn T5= R2+ 20 mg Zn/d T6= R2+ 30 mg Zn/d

^{a,b} Means in the same row with different superscripts are significantly different (P<0.05).

Table (6): Economical evaluation of the tested rations.

		R1			R2	
Items	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Total body weight gain (kg)	20.70	21.54	22.39	19.76	21.43	21.46
Total revenue (L.E.)	372.6	387.72	403.02	355.68	385.74	386.28
Total feed intake (kg/h)	202.55	205.46	195.78	202.24	195.11	198.22
Price / kg feed (L.E.)	1.09	1.09	1.09	0.96	0.96	0.96
Feed cost/ kg gain (L.E.)	10.67	10.40	9.53	9.83	8.74	8.87
Total feed cost (L.E.)	220.78	223.95	213.40	194.15	187.31	190.29
Net revenue (L.E.)	151.82	163.77	189.62	161.53	198.43	195.99
Economical efficiency*	1.69	1.73	1.89	1.83	2.06	2.03

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تأثير إضافة الزنك علي أداء و صفات الذبيحة للحملان النامية المغذاه على علائق تحتوي على مستويات مختلفة من البروتين

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١. قسم الإنتاج الحيواني ، كلية الزراعة ، جامعة القاهرة ، الجيزة، ج م ع
٢. معهد بحوث الإنتاج الحيواني ، مركز البحوث الزراعية ، الدقي ، الجيزة ، ج م ع

اشتملت هذه الدراسة على تجربتين الأولى تجربة تمثيل غذائي و الثانية تجربة تغذية تطبيقية على العلائق التي تم تقييمها من خلال تجارب التمثيل الغذائي . استخدم في التجربة الأولى عدد ٦ كباش فرافرة بمتوسط وزن٤٣,٦ ± ٣,٦ كجم قسمت إلى مجموعتين (ثلاث كباش في كل مجموعة) لتقييم ٦ علائق الأولى (١٤% بروتين بدون إضافة زنك)، الثانية (١٤% بروتين مع ٢٠ مجم زنك/حيوان/يوم)، الثالثة (١٤% بروتين مع ٣٠ مجم زنك/حيوان/يوم)، الرابعة (١٠% بروتين بدون إضافة زنك)، الخامسة (١٠% بروتين مع ٢٠ مجم زنك/حيوان/يوم) و السادسة (١٠% بروتين مع ٣٠ مجم زنك/حيوان/يوم) و أضيف الزنك في صورة كبريتات الزنك. و من النتائج المتحصل عليها في تجربة التمثيل الغذائي وجدت زيادة في معامل هضم البروتين و ميزان النيتروجين و البروتين الخام المهضوم في العلائق المحتوية على ١٤% بروتين خام عن العلائق المحتوية على ١٠% بروتين خام. إضافة الزنك مع ١٠% بروتين أدت إلى زيادة معنوية في معاملات هضم كل من البروتين و مستخلص الأثير و كذلك البروتين الخام المهضوم، في حين لم يكن لمستوى إضافة الزنك مع مستويي البروتين (١٠ و١٤ %) في العلائق تأثير معنوي على معامل هضم كل من المادة العضوية، الألياف الخام، المستخلص الخالي من الأزوت و كذلك مجموع المركبات الغذائية المهضومة.

و في تجربة النمو تم اختيار ٣٠ حولي فرافرة (بمتوسط وزن ٢٢,١٩ كجم ، عمر ٥ شهور) قسمت عشوائيا إلى ٦ مجموعات (٥ حولي في كل مجموعة) و أستمرت التجربة لمدة ٦ شهور. خلال ١١٢ يوما الأولى من التجربة الحوالي المغذاه على ١٤% بروتين مع إضافة الزنك بمستوييه كانت أسرع في معدل النمو عن الحوالي المغذاه على ١٠% بروتين مع إضافة الزنك بمستوييه ولكن أظهرت النتائج في نهاية التجربة عدم وجود تأثير معنوي لإضافة الزنك أو مستوى البروتين على كل من الزيادة الكلية في وزن الجسم، الزيادة اليومية في الوزن، المادة الجافة المأكولة و كذلك معدل التحويل الغذائي. لم يتأثر معنويا كل من وزن الجسم الفارغ، وزن الذبيحة و كذلك نسبة التصافي بمستوى البروتين أو مستوى الزنك. في حين أدت إضافة الزنك إلى زيادة نسبة اللحم و خفض نسبة الدهن في الذبيحة. العليقة المحتوية على ١٠% بروتين و مستوى الإضافة ٢٠ مجم زنك/حيوان/يوم كانت أعلى العلائق كفاءة اقتصادية و كانت أقلهم العليقة المحتوية على ١٤% بروتين و بدون إضافة الزنك.

بصفة عامة إضافة الزنك أدت إلى تحسين الهضم، القيمة الغذائية و الكفاءة الإقتصادية لعلائق الحملان النامية و بصفة خاصة مع العلائق المحتوية على ١٠% بروتين خام.