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Effect of High Energy and High Protein Diets on Zinc and Copper Metabolism in Goats

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Abstract

The effect of different levels of energy and protein on the utilization of zinc and copper were evaluated in four metabolic experiments. A total of nine growing castrated male balady kids having nearly the same age (8-9 months) and body weight (15-18kg) were experimented on. Kids were housed individually in metabolism cages in order to collect feces and urine. Four experiments, 3 trials per each were done on the same animals, with about 10 days as a rest period between one experiment and another, in which the animals were fed on control ration during the interval. The nine kids were randomly divided into 3 groups (A, B and C), 3 kids per each. The first group (A) was fed the control ration and used as control, while the other two groups (B and C) were fed the tested rations which furnished 15

Index terms— energy, protein, zinc, copper, metabolism, goats.

1 Introduction

here is no doubt that considerable increase in animal production can be achieved with improved nutrition and management practices under different production systems of management 1 . Efficient utilization of nutrients depends on an adequate supply of energy, which of paramount importance in determining the productivity. In goats, energy deficiency retards kids growth, delays puberty, reduces fertility 2 . With continued energy deficiency, the animals show a concurrent reduction in resistance to infectious diseases and parasites. The problem may be further complicated by deficiencies of protein, minerals and vitamins. Energy limitation may result from inadequate feed intake. Low energy intake that result from either feed restriction or low diet component digestibility prevent goats from meeting their requirements and from attaining their genetic potential. Goats are more active and travel greater distances than sheep, which increases energy requirements, high water content of forages may also become a limiting factor 3 . Protein deficiencies in the diet deplete stores in the blood, liver and muscles and predispose animal to a variety of serious and even fatal aliments. The further protein deficiency reduces rumen function and lower the efficiency of feed utilization 2 . Mineral requirements for animals is affected by many aspects, such as nature and level of production, age, level and chemical form of elements, breed and animal adaptation 4 . The bioavailability of trace-elements to animals can be affected by a variety of dietary components, one of these components is protein 5 .

Copper deficiency is a serious problem for grazing ruminant in many countries of the world due to both low concentration of the element in the forage as well as to elevated amount of molybdenum and sulfur which interfere with copper utilization 6 . The present study was carried out to investigate the effect of different levels of energy and protein on the metabolism of zinc and copper.

2 II.

3 Materials and Methods

4 a) Animals and housing

A total number of nine growing castrated male balady kids to be nearly of the same age (8-9 months) and body weight (15-18 kg) were used in this study. Each kid was kept in an individual metabolic cage allowing the collection of feces and urine separately. A weighed daily ration was offered to each animal in its respective feed trough and tap water freely available.

5 b) Rations and Feeding

This study was carried out in four experiments, each experiment had 3 trials and each trial durated 30 days. Before starting the experiments, the kids were fed a balanced ration (control ration) for three weeks in order to accustom the animals on the ration and to assume the repletion of body mineral store. The control ration was formulated to contain the recommended levels of digestible energy (DE) 2.94 Mcal/kg, crude protein (CP) 9.51%, zinc 63.55 ppm and copper 16.72 ppm according to the NRC3 for goats. The preliminary period was extended for 21 days, while the collection period was extend for 8 days. During the collection period, the daily fecal matter excreted and the daily amount of urine were separately collected, measured, sampled and prepared for further chemical analysis. A G fixed weight of the ration was offered to each animal and the daily feed intake was calculated. The experiments were carried on the same groups and separated by a rest period of 10 days, during which the kids were fed on control ration. Nine test rations varying in their energy and protein levels were fed to the kids during the metabolism study as shown in the design in Table 1. The nine kids were randomly divided into 3 groups (A, B and C), 3 kids per each. The first group (A) was fed the control ration and used as control, while the other two groups (B and C) were fed the tested rations which furnished 15% more or less DE and CP than the control. The physical and chemical composition of the nine tested rations and energy values (DE) were shown in Tables 3 and 4, while Table 2 shows the chemical composition and energy value of the ingredients used in formulating of the experimental rations. The total amount of the daily fecal matter excreted per animal was collected daily at 8.00am before feeding. The freshly collected fecal matter of each animal was weighed, recorded, mixed thoroughly and then representative sample (10%) was taken and dried in hot air oven at 60C for about 24h. The dried fecal samples from each animal were thoroughly mixed finely ground and stored at room temperature for further chemical analysis.

6 d) Urine samples

The daily urine excreted by the kids was collected at 8.00am and measured in graduated cylinder to record its volume. The collected amount from each animal was then thoroughly mixed and two representative samples, 100ml each was taken and acidified with 2ml of concentrated hydrochloric acid, then kept in refrigerator at 4°C for further chemical analysis.

7 e) Metabolism trials

In the simple form of the balance technique, the intake of the element under study is compared with the fecal output from the animal's body and the difference is assumed to be absorbed by the animal (apparent absorption) which may then be expressed as a percentage of the dietary intake or in g or mg/head/day.

8 Intake -fecal excretion

Apparent absorption = ————————————-× 100 Intake Intake -(fecal excretion + urinary excretion)
Apparent retention = - **??**—————————————————————-× 100 Intake (Ammerman et al) 6 f)
Minerals determination in feces and urine Duplicate samples of 1gm feces and 10ml of urine were ashed with 20ml acid mixture (2 parts concentrated nitric acid + 1 part concentrated perchloric acid) and then digested on hot plate for 1.5-2h until the color become clear and volume reduced to the minimum. The ashed samples were diluted with bidistilled water in clean dry tightly closed glass bottles 100ml capacity and then stored for subsequent minerals determination. The zinc and copper in the prepared samples of fecal matter were measured in ppm and of urine in mg/L by atomic absorption/flame emission spectrophotometer using an air-acetylene flame and hallow cathode lamp after method described by Slavin 8 .

9 III.

10 Results and Discussion

The metabolic balances of zinc and copper in the four experiments are presented in Tables 5 and 6.

11 Experiment I

Kids group fed high protein showed slight increase in the amount of zinc intake and in the excreted zinc in both feces and urine compared with control. The increased urinary Zn excretion by high protein diet was similar to the findings of Greger and Snedeker 5 who reported that high protein diet increased urinary zinc excretion and attributed that to a greater amount of histidine and cystine in the high protein ration. The apparent absorption and retention of Zn were increased when dietary protein levels increased as reported by Gawthorne et al 9 . Feeding high or low protein rations increased the amount of Cu intake, Cu excretion in feces and urine compared to control. The apparent Cu absorption and retention percentages were decreased in kids group fed the NEHP ration, while increased in group fed on NELP ration compared with control. The increase dietary crude protein is responsible for the formation of insoluble copper sulfide during rumen fermentation resulting in lower solubility and absorption of Cu 10,11 .

Experiment II High energy-high protein ration slightly increased the amount of Zn intake, fecal and urinary Zn excretion than control one. The increase of fecal Zn excretion in kids fed HEHP ration may be due to high Zn intake as reported by McDowell12 who reported that the fecal endogenous Zn increases with the increased Zn intake. The apparent Zn absorption was increased in HENP & HEHP rations, while the apparent retention was decreased in kids group fed HENP. Feeding high energy ration decreased the amount of Cu intake, fecal and urinary Cu excretion compared to control. The apparent absorption and retention of Cu were slightly increased in kids group fed HENP ration.

12 Experiment III

Feeding the HELP ration was decreased the amount of Zn intake, zinc excreted in feces and urine compared to control one. The apparent Zn absorption and retention were increased in group fed HELP ration, while decreased in group fed LENP. The decrease in absorption percentage in low energy ration may be due to high zinc intake 13 . Feeding low energy ration increased the amount of Cu intake, fecal and urinary excretion compared to HELP and control one. The apparent absorption and retention of Cu were decreased in kids group fed LENP ration.

13 Experiment IV

Kids fed the LEHP and LELP rations showed a slight increased in the amounts of Zn intake, Zn excreted in both feces and urine compared to control. The apparent absorption and retention of Zn were decreased in kids group fed the LEHP and LELP rations compared to control. On this respect, many authors reported that, the apparent Zn absorption and retention were increased when dietary protein levels were increased 9. Kids fed on LEHP ration recorded the highest amount of Cu intake and excretion in feces and urine compared to LELP and control one. The apparent absorption and retention were decreased in kids group fed the LEHP compared to the control one. These findings were in accordance with that found by Ward 10 and Ivans and Veira11 who found that the increase in dietary CP resulting in lower solubility and absorption of Cu in sheep. The summarized effect of energy and protein levels revealed that feeding HENP ration increased the apparent absorption and retention of Cu, while the [1]

Figure 1: T

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Experiment	Trial	Group	DE (Mcal/kg diet)	CP (%)	Ration
	1	A	2.94	9.51	1 NENP*
I	2	B	2.96	10.79	2 NEHP
	3	C	2.93	8.08	3 NELP
	1	A	2.94	9.51	1 NENP
II	2	B	3.39	9.54	4 HENP
	3	C	3.40	11.00	5 HEHP
	1	A	2.94	9.51	1 NENP
III	2	B	3.37	8.14	6 HELP
	3	C	2.53	9.59	7 LENP
	1	A	2.94	9.51	1 NENP
IV	2	B	2.58	10.80	8 LEHP
	3	C	2.51	8.06	9 LELP

*[Note: *NE=normal energy, HE=High energy, LE=Low energy, NP=normal protein, HP=high protein, LP=low protein]*

Figure 2: Table 1 :

2

Ingredient	DM			Chemical composition (%)				(ppm)		DE (Mcal/kg
		OM	CP	EE	CF	NFE	Ash	Cu	Zinc	
Yellow corn	89.7	97.88	9.6	4.16	2.77	81.35	2.12	3.5	12.8	3.84
Soybean meal	91.3	93.09	47.0	5.47	7.44	33.18	6.91	22.8	42.9	3.88
CSM	92.5	95.40	27.0	6.40	24.5	37.50	4.60	19.9	62.2	2.65
Wheat bran	90.65	93.00	15.6	4.70	8.37	64.33	7.00	12.7	113.7	3.09
Wheat straw	90.0	86.70	3.5	1.66	38.0	43.54	13.30	3.2	5.6	1.94
Limestone	98.0	-	-	-	-	-	100	-	-	-
Common salt	98.0	-	-	-	-	-	98.00	-	-	-
Mineral mixture	98.0	-	-	-	-	-	98.00	10	40	-
AD3E	98.0	-	-	-	-	-	-	-	-	-

Figure 3: Table 2 :

3

Ingredients

Figure 4: Table 3 :

4

Rations	DM			experimental rations Chemical composition	(%)			(ppm)		DE (Mcal/kg)
		OM	CP	EE	CF	NFE	Ash	Cu	Zinc	
1	90.14	91.41	9.51	3.22	17.92	60.76	8.59	16.72	63.55	2.94
2	90.14	91.19	10.79	3.19	18.36	58.85	8.81	17.23	61.72	2.96
3	90.07	91.48	8.08	3.11	18.33	61.96	8.52	15.79	59.07	2.93
4	90.01	94.08	9.53	3.71	9.83	71.01	5.92	15.88	60.98	3.39
5	90.03	93.79	11.00	3.70	9.98	69.11	6.21	16.57	61.47	3.40
6	89.91	93.99	8.14	3.55	10.24	72.06	6.01	14.88	56.80	3.37
7	90.27	88.91	9.59	2.76	25.77	50.79	11.09	17.68	67.26	2.53
8	90.34	89.27	10.80	2.91	25.23	50.33	10.73	18.25	65.30	2.58
9	90.25	89.11	8.06	2.74	25.98	52.33	10.89	16.86	63.97	2.51
c) Fecal samples										

Figure 5: Table 4 :

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Item	Experiment I			Experiment II			Experiment III			Experiment IV	
	NENP	NEHP	NELP	NENP	HENP	HEHP	NENP	HELP	LENP	NENP	LEHP	LELP
Zn intake	29.26	30.08	29.55	31.84	30.47	32.38	32.7	30.61	35.63	34.42	35.53	35.61
Fecal Zn	17.43	17.7	17.41	18.87	17.95	19.00	19.31	17.77	21.09	20.02	20.74	20.80
Urinary Zn	3.00	3.05	2.96	2.94	2.97	3.18	2.84	2.76	3.03	2.90	2.98	2.94
Absorbed	11.83	12.37	12.14	12.97	12.52	13.38	13.57	13.02	14.54	14.40	14.79	14.81
Zn	8.83	9.32	9.18	10.03	9.55	10.20	10.73	10.26	11.51	11.5	11.81	11.87
Retained	30.43	41.12	41.08	40.73	41.08	41.32	41.5	42.52	40.81	41.84	41.63	41.59
Zn	(100)*	(101.17)	(101.61)	(100)	(100.86)	(101.45)	(100)	(102.46)	(98.34)	(100)	(99.50)	(99.4)
Absorption	30.18	30.98	31.07	31.50	31.34	31.50	32.81	33.52	32.30	33.41	33.24	33.33

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Figure 6: Table 5 :

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Item		Experiment I			Experiment II		Experiment III				Experiment	
	NENP	NEHP	NELP	NENP	HENP	HEHP	NENP	HELP	LENP	NENP	LEHP	LE
Cu intake	8.54	9.32	8.77	9.29	8.81	9.70	9.54	8.92	10.37	10.05	10.99	10.
Fecal Cu	4.24	4.74	4.28	4.66	4.36	4.90	4.73	4.40	5.18	4.99	5.70	5.1
Urinary Cu	0.65	0.79	0.68	0.88	0.79	0.86	0.82	0.83	0.87	0.95	1.09	0.9
Absorbed	4.30	4.58	4.49	4.63	4.45	4.80	4.81	4.52	5.19	5.06	5.29	5.2
Cu	3.65	3.79	3.81	3.75	3.66	3.94	3.99	3.69	4.30	4.11	4.20	4.3
Retained	50.35	49.14	51.20	49.84	50.51	49.48	50.42	50.67	50.05	50.35	48.13	50.
Cu	(100)*	(97.6)	(101.69)	(100)	(101.34)	(99.28)	(100)	(100.50)	(99.27)	(100)	(95.59)	(10
Absorption	42.74	40.66	43.44	40.36	41.54	40.62	41.82	41.37	41.47	40.8	38.22	41.
%	(100)*	(95.13)	101.64)	(100)	(102.92)	(100.64)	(100)	(98.92)	(99.16)	(100)	(93.68)	(10
Retention												
%												

Absorbed = intake -fecal Retained = intake -(fecal + urinary)

*[Note: *]*

Figure 7: Table 6 :

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