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Various Copper Levels Effect on the Digestibility and the Use of Nutrients in the Fodder by Pregnant Ewes

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Abstract

In the light of the newly established norms of copper content for pregnant meat-and-lard ewes, the effect of various levels of the content of this element in the diets of ewes on the digestibility and the use of nutrients in various periods of pregnancy has been determined during the physiological experiments.

Keywords: ewes, pregnant, norm, copper, digestibility, nutrients, nitrogen, calcium, phosphorus.

Introduction

A pregnant woman needs to have more red blood cells to carry oxygen around her body and her baby's (Aboud, et al., 2019; Selem, et al., 2018; Minodora, et al., 2020; Moeini, et al., 2018). It is known that the mother's body is the medium in which the fetus goes through a series of development phases. With that, in each phase, the requirements of the developing organism to the environmental conditions change in a certain way. The studies (Gayirbegov, 2002; Kokorev, 1994; Lapshin, 1967) showed that during pregnancy, with increasing the needs of the growing fetus in nutrients, the intensity of metabolism in the mother's organism increased.

Besides, the authors noted that an increase in the digestibility of dry matter, protein, fat, and nitrogen-free extractives, and a decrease in the digestibility of fiber occurred in the ewes in the last third of pregnancy.

It is also known that minerals, including copper, also contribute to increasing the digestibility of nutrients from the diet (Kokorev, 1994; Andreev, 1997).

In this regard, the work was aimed at studying the effect of various levels of copper in the diets, given the newly established norms (Tyapugin, 2018), on the digestibility and the use of the nutrients in the diets of meat-and-lard ewes during various periods of their pregnancy in the arid zone of Russia.

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Methods

To accomplish this task, a scientific and economic experiment, and, on this background, physiological experiments with the Kalmyk fat-tailed ewes at the beginning, in the middle, and at the end of their pregnancy were made at the Buddha peasant farm in the Republic of Kalmykia.

The scientific and economic experiment was made according to the following scheme (Table 1).

For the experiment, 30 pregnant ewes were chosen in groups of 10 ewes each with a live weight of 57 – 60 kg, following the principle of analogs. During this experiment, at the beginning (45 days), in the middle (100 days), and at the end (140 days) of pregnancy, balance experiments were made, and during each of these periods of pregnancy, three ewes were chosen from each group. During the balance experiments, all of them were in the same feeding and keeping conditions; their feeding conditions differed only in the content of copper in the diets. At the beginning of pregnancy, the animals in the first experimental group received the main diet with the copper content within the norms recommended by the RAAS (Kalashnikov et al., 2003) in the amount of 12.74 mg per animal per day; in the middle of pregnancy — 13.51 mg per animal per day, and at the end of pregnancy — 14.7 mg per animal per day, i.e., by 30 % less than the norm established by the authors earlier. The ewes in the second group received copper according to the previously established norm: at the beginning of pregnancy — 18.2 mg per animal a day, in the middle of pregnancy — 19.3 mg per animal a day, and at the end of pregnancy — 21 mg per animal a day; 23 – 27 mg of copper sulfate was added to the main diet. The ewes in the third group received copper by 30 % above the norm: at the beginning of pregnancy — 23.66 mg per animal a day, in the middle of pregnancy — 25.10 mg per animal a day, and at the end of pregnancy — 27.30 mg per animal a day, through adding 46 – 54 mg of copper sulfate to the main diet. Copper sulfate was fed to the ewes every day in a mixture with concentrates and other mineral additives.

During the chemical analyses of the balance experiment sample, generally adopted methods were used.

Table 1. The scheme of the scientific and economic experiment

Pregnancy periods	The level of copper in the diet, mg		
	Low	Optimal (norm)	High

Beginning	12.74 (-30%)	18.2	23.66 (+30%)
Middle	13.51 (-30%)	19.3	25.10 (+30%)
End	14.70 (-30%)	21.0	27.30 (+30%)

Results and Discussion

As a result of the studies, it was found that the digestibility of individual nutrients significantly changed with the progress of ewes' pregnancy (Table 2). For instance, during pregnancy, the digestibility of dry matter increased by 1.43 – 3.1 % ($p < 0.05$), of organic matter — by 2.2 – 3.73 % ($p < 0.01$), of crude protein — by 1.93 – 3.48 % ($p < 0.05$), of crude fat — by 0.44 – 0.92 % ($p < 0.05$), and of nitrogen-free extractive substances — by 5.01 – 9.69 % ($p < 0.01$). The digestibility of crude fiber decreased during pregnancy by 2.95 – 3.64 % ($p < 0.05$).

Table 2. The effect of copper content on the coefficients of nutrients digestibility

Groups	Dry matter	Organic matter	Crude protein	Crude fat	Crude fiber	BAS
The beginning of pregnancy						
1	63.69 ± 0.29	65.92 ± 0.16	60.90 ± 0.64	58.70 ± 0.37	54.90 ± 0.47	73.79 ± 0.22
2	67.06 ± 0.14	69.27 ± 0.09	63.57 ± 0.12	61.99 ± 0.08	57.85 ± 0.07	77.52 ± 0.29
3	64.80 ± 0.41	67.00 ± 0.13	61.95 ± 0.14	59.32 ± 0.11	55.79 ± 0.17	74.94 ± 0.14
The middle of pregnancy						
1	64.00 ± 0.14	66.30 ± 0.27	62.05 ± 0.16	57.95 ± 0.21	53.78 ± 0.25	73.77 ± 0.55
2	67.96 ± 0.54	71.02 ± 0.44	65.70 ± 0.36	61.66 ± 0.44	56.12 ± 0.21	79.89 ± 0.94
3	65.20 ± 0.39	68.05 ± 0.31	63.17 ± 0.55	59.81 ± 0.45	54.02 ± 0.50	76.39 ± 0.51
The end of pregnancy						
1	65.12 ± 0.44	68.50 ± 0.76	63.19 ± 0.63	59.14 ± 0.62	51.29 ± 0.73	79.07 ± 1.05
2	69.28 ± 0.19	73.00 ± 0.44	67.05 ± 0.37	62.90 ± 0.25	54.90 ± 0.37	84.18 ± 0.88
3	67.90 ± 0.45	69.20 ± 0.39	63.88 ± 0.34	60.24 ± 0.22	52.15 ± 0.15	79.95 ± 0.79

A comparison of the coefficients of digestibility in the groups showed that various levels of copper had a marked effect on these indicators. For instance, increasing the content of this element in the diets of the ewes in the second group to the optimal norm contributed to a significant increase in the digestibility of the dry matter by 3.37 – 4.15 % ($p < 0.05$), of organic matter — by 3.35 – 4.72 % ($p < 0.05$), of crude protein — by 2.67 – 3.86 % ($p < 0.05$), of crude fat — by 3.29 – 3.76 % ($p < 0.05$), of crude fiber — by 2.95 – 3.61 % ($p < 0.05$), and of BAS — by 3.73 – 6.12 % ($p < 0.05$), compared to the animals in the first group that received 30 % less copper than the established norm. Increasing the copper content in the diets of the ewes in the third group by the same amount above the norm had no significant effect on the digestibility of nutrients by the pregnant ewes.

Besides, the studies also showed that the degree of nitrogen digestion by the ewes from the diets increased due to pregnancy and optimization of the amount of copper in the diets (Table 3). For instance, while at the beginning of pregnancy, the degree of this element digestion by the ewes was 16.95 – 29.31 % of the adopted value, at the end of pregnancy, it increased to 18.31 – 31.00 %. The results of analyzing the samples of balance experiments also showed a positive effect of the optimal content of copper on nitrogen absorption by pregnant meat-and-lard ewes. For instance, the second group of ewes that received copper in the diet according to the established norm retained 1.7 – 1.8 times more nitrogen ($p < 0.001$) in their organisms, compared to their peers in the first group. The percentage of nitrogen digestion from the fodder by the ewes in this group was also higher at the beginning of pregnancy by 12.36 % ($p < 0.001$), in the middle of pregnancy — by 13.28 % ($p < 0.001$), and at the end of pregnancy — by 12.7 % ($p < 0.001$), compared to the first group.

Table 3. Nitrogen digestion by the ewes from the diets, g

Group	Taken with the fodder	Excreted		Total	Digested	% of digestion from the taken
		with feces	with urine			
The beginning of pregnancy						
First	23.65 ± 0.04	9.24 ± 0.14	10.40 ± 0.22	19.64 ± 0.15	4.01 ± 0.11	16.95 ± 0.50
Second	23.71 ± 0.02	8.63 ± 0.03	8.13 ± 0.06	16.76 ± 0.10	6.95 ± 0.08	29.31 ± 0.37
Third	23.60 ± 0.04	9.00 ± 0.03	10.20 ± 0.27	19.20 ± 0.24	4.40 ± 0.20	18.64 ± 0.88
The middle of pregnancy						
First	39.42 ± 0.09	14.95 ± 0.06	17.71 ± 0.41	32.66 ± 0.36	6.76 ± 0.32	17.15 ± 0.83

Second	39.47 ± 0.02	13.53 ± 0.13	13.93 ± 0.03	27.46 ± 0.14	12.01 ± 0.17	30.43 ± 0.42
Third	39.32 ± 0.10	14.51 ± 0.22	16.70 ± 0.32	31.21 ± 0.09	8.11 ± 0.12	20.62 ± 0.29
The end of pregnancy						
First	48.12 ± 0.08	17.71 ± 0.3	21.60 ± 0.70	39.31 ± 0.44	8.81 ± 0.40	18.31 ± 0.85
Second	48.34 ± 0.08	15.92 ± 0.15	17.43 ± 0.41	33.35 ± 0.28	14.99 ± 0.19	31.00 ± 0.42
Third	48.44 ± 0.04	17.49 ± 0.16	20.74 ± 0.43	38.23 ± 0.28	10.21 ± 0.31	21.08 ± 0.63

The conducted studies showed that the retention of calcium and phosphorus in the organisms of the ewes was significantly determined by the period of their pregnancy and the content of copper in the diet (Tables 4 and 5). For instance, calcium retention increased during pregnancy. While at the beginning of pregnancy of the ewes, it was equal to 3.3 – 4.9 g, or 52.88 – 78.02 % of the calcium taken with the fodder, in the middle of pregnancy, it was 3.98 – 5.69 g or 54.59 – 78.27 %, and at the end of the period, it was 4.13 – 6.0 g, or 55.06 – 79.05 %, respectively ($p < 0.05$).

Comparison of the data of various groups showed that the best use of this element both in the absolute (4.9 – 6.0 g) and relative (78.02 – 79.05 %) terms was noted in the ewes from the second group on the background of the optimal amount of copper in their diet. The animals that received insufficient and excessive amounts of copper retained less calcium in their organisms.

The data about the use of phosphorus by pregnant ewes were also of certain interest. It should be noted that the balance of this element, the same as that of calcium, was positive. The retention of phosphorus in the organisms of the ewes increased during pregnancy. For instance, while at the beginning of pregnancy, 1.4 – 2.0 g of phosphorus was retained in the organisms of the ewes, in the middle of pregnancy, this value was 1.70 – 2.61 g, and at the end of pregnancy – 2.16 – 3.10 g ($p < 0.05$). The percentage of its retection during the pregnancy of the ewes increased from 38.46 – 54.79 % at the beginning of pregnancy to 48.11 – 69.50 % at the end of pregnancy ($p < 0.05$).

Table 4. The use of calcium from the diets by the ewes, g

Group	Taken with the fodder	Excreted		Total	Retained in the organism	% retained from the taken with the fodder
		with feces	with urine			
The beginning of pregnancy						
First	6.24 ± 0.03	1.36 ± 0.05	1.58 ± 0.18	2.94 ± 0.14	3.30 ± 0.15	52.88 ± 2.39
Second	6.28 ± 0.02	1.07 ± 0.02	0.31 ± 0.03	1.38 ± 0.05	4.90 ± 0.06	78.02 ± 0.87
Third	6.37 ± 0.01	1.16 ± 0.03	0.81 ± 0.06	1.97 ± 0.09	4.40 ± 0.08	69.07 ± 1.39
The middle of pregnancy						
First	7.29 ± 0.06	2.32 ± 0.04	0.99 ± 0.02	3.31 ± 0.03	3.98 ± 0.02	54.59 ± 0.44
Second	7.27 ± 0.02	1.23 ± 0.04	0.35 ± 0.03	1.58 ± 0.05	5.69 ± 0.03	78.27 ± 0.67
Third	7.25 ± 0.02	1.16 ± 0.02	0.98 ± 0.01	2.14 ± 0.01	5.11 ± 0.02	70.48 ± 0.19
The end of pregnancy						
First	7.50 ± 0.15	2.23 ± 0.23	1.14 ± 0.01	3.37 ± 0.22	4.13 ± 0.06	55.06 ± 2.00
Second	7.59 ± 0.16	0.98 ± 0.15	0.61 ± 0.02	1.59 ± 0.15	6.00 ± 0.20	79.05 ± 1.99
Third	7.32 ± 0.09	1.32 ± 0.01	0.80 ± 0.04	2.12 ± 0.06	5.20 ± 0.15	71.04 ± 1.16

Increasing the level of copper in the diets of the ewes to the optimal level resulted in a slight increase in phosphorus retention in the organisms of the ewes. At the beginning of pregnancy, this difference was 0.6 g, in the middle of pregnancy — 0.91 g, and at the end of pregnancy — 0.94 g. Further increase of the level of copper had no significant effect on the use of phosphorus, but caused an increase in its retection in the organisms of the ewes, compared to the ewes that received copper below the established norms: at the beginning of pregnancy — by 0.25 g, in the middle of pregnancy — by 0.20 g, and at the end of pregnancy — by 0.38 g.

Table 5. The use of phosphorus from the diets by the ewes, g

Group	Taken with the fodder	Excreted		Total	Retained in the organism	% retained from taken with the fodder
		with feces	with urine			
The beginning of pregnancy						
First	3.64 ± 0.01	1.46 ± 0.03	0.78 ± 0.01	2.24 ± 0.04	1.40 ± 0.03	38.46 ± 0.98
Second	3.65 ± 0.05	1.22 ± 0.13	0.43 ± 0.02	1.65 ± 0.15	2.00 ± 0.15	54.79 ± 4.24

Third	3.64 ± 0.01	1.34 ± 0.02	0.65 ± 0.02	1.99 ± 0.04	1.65 ± 0.03	45.33 ± 1.06
The middle of pregnancy						
First	3.84 ± 0.01	1.33 ± 0.05	0.81 ± 0.01	2.14 ± 0.04	1.70 ± 0.05	44.27 ± 1.30
Second	3.83 ± 0.01	0.85 ± 0.10	0.37 ± 0.01	1.22 ± 0.11	2.61 ± 0.10	68.14 ± 2.99
Third	3.81 ± 0.01	1.24 ± 0.09	0.67 ± 0.02	1.91 ± 0.09	1.90 ± 0.10	49.87 ± 2.65
The end of pregnancy						
First	4.49 ± 0.02	1.61 ± 0.15	0.72 ± 0.01	2.33 ± 0.17	2.16 ± 0.15	48.11 ± 3.58
Second	4.46 ± 0.02	0.84 ± 0.07	0.52 ± 0.01	1.36 ± 0.07	3.10 ± 0.08	69.50 ± 1.76
Third	4.44 ± 0.01	1.07 ± 0.12	0.83 ± 0.02	1.90 ± 0.23	2.54 ± 0.22	57.21 ± 5.15

Conclusion

Thus, optimization of the copper amount in the diets of pregnant ewes improves the digestibility of the nutrients, the absorption of nitrogen, and the use of calcium and phosphorus from the diets during pregnancy.

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