Influence of innovative calcium-containing additive on growth and development of heifer replacement

IOP Conf. Series: Earth and Environmental Science **315** (2019) 062020 doi:10.1088/1755-1315/315/6/062020

Influence of innovative calcium-containing additive on growth and development of heifer replacement

E M Kislyakova, S L Vorobyova and S I Kokonov

Izhevsk State Agricultural Academy, Izhevsk, Russia

E-mail: mullan@inbox.ru

Abstract. The comparative effect of the use of various physical forms of calcium gluconate on the growth and development of heifer replacement has been studied. Calcium-MAG is a nanodispersed nanostructured amorphous form of calcium salt of gluconic acid with a dispersion of tens to hundreds of nanometers and sizes of agglomerates not exceeding 500 nm. It is established that the use of calcium gluconate of various forms in diets promotes the growth of heifer replacement. Thus, the absolute growth of live weight in the animals of experimental groups in the main period of the experiment was 3.1 to 7.8% higher than in the control group. At the same time, the heifers that received Calcium-MAG were characterized by great superiority (7.8%). The positive effect of calcium gluconates was also observed in further age periods, which led to a statistically significant difference in live weight between the control and second experimental group at the age of 18 months by 7.1 ($P \geq 0.99$) and 2.6%, respectively. The animals of the second experimental group were 10.9% and 2.9% more than their average counterparts in the control group ($P \geq 0.99$) and the first test group, respectively, in terms of the average daily weight gain. Observations showed that the height at the withers in animals, both at the age of 12 months and at the age of 18 months in the second test group was significantly higher than in the control group by 2.7 cm and 3.8 cm, respectively. A similar trend was observed in measuring the depth of the chest. A significant difference in this measurement was established between the animals of the control group and the second test group. At the age of 12 months, the advantage was 3.6 cm, at the age of 18 months - 2.6 cm ($P \geq 0.999$). The use of mechanically activated calcium gluconate in rations of heifer replacement at an early age contributes to their better growth, preserving the aftereffect in subsequent periods.

1. Introduction

The rational system of growing young animals, taking into account its biological characteristics, should promote normal growth, development, the formation in the future of high dairy productivity and a strong constitution. One of the main elements of the technology is the organization of high-grade feeding. Mineral elements play a huge role in the system of high-grade feeding [1–3].

For a living organism, many macro - and microelements are vital, and a deficiency or excess or imbalance of any of them can lead to a metabolic disorder. A characteristic feature of mineral substances is that they are not synthesized in living organisms and must regularly be fed with feed and water. In addition, most essential macro- and microelements are not able to accumulate in the body of animals, even with their high content in the external environment [1, 4, 5]. The main source of mineral substances for animals are plant foods. However, in some foods, mineral substances are in difficult to digest form or antagonists are present in them.

So far, the problem of creating calcium-containing compounds, which would have been highly effective in normalizing calcium metabolism, remains urgent. Calcium acts as the driving force of metabolism. Calcium ions have dimensions that allow them to enter the cell, carrying a chain of nutrients with them, interact with other substances, providing the body with energy for life and growth. It normalizes the metabolism, the work of the nervous system, cardiac activity, the work of the musculoskeletal system, activate lipase of the pancreas, saline phosphatase and a number of enzymes in the cellular structures, stabilize trypsin in intestinal chyme.

2. Material and methods of research

Scientists of the Physico-Technical Institute of the Ural Branch of the Russian Academy of Sciences in Izhevsk (G.N. Konygin, E.P. Elsukov, D.S. Rybin, 2008) for the first time in the world received nanodispersed nanostructured amorphous form of calcium gluconic acid salt (mechanically activated calcium gluconate) with dispersion from tens to hundreds of nanometers and sizes of agglomerates not more than 500 nm [6–9]. At present, mechanically activated calcium gluconate (Calcium-MAG) has passed state registration and has a certificate that allows it to be used as a biological supplement. In medical research a number of scientists have established that there is the best absorption of calcium by human organism when using the calcium gluconate of ultramicroscopic structure in comparison with the traditional form of the drug [1].

The aim of the studies was determination of the comparative effect of the use of various physical forms of calcium gluconate on the growth and development of heifers replacement. The research was carried out in the JSC "Uchkhoz Iyulskoye" of Izhevsk state agricultural academy in Votkinsky district of the Udmurt Republic.

For the scientific and economic experience, three groups of heifers were formed by the method of similar groups. Rations of calves were identical for the main set of feed. The animals of the first test group were additionally supplemented with calcium gluconate in the traditional form (2 g), the animals of the second test group were additionally supplemented with Calcium MAG in a similar dosage. Monitoring of the growth intensity of the experimental young animals was carried out on the basis of monthly individual weighing. The animals were evaluated according to nine basic measurements: height at the withers, height at hips, chest depth, chest breadth, width in hips, width of loin, oblique body length, chest girth, girth of the pastern. Biometric processing of the results of the research was carried out using the Microsoft Exel program using the generally accepted formulas.

3. Results and discussion

Calves from the moment of birth until the age of six months are growing vigorously, they form the skeleton, the muscular system, the internal organs, so their feeding should have high biological value.

As a result of the conducted researches it is established that the use of various forms of calcium gluconate in rations promotes the growth of heifers' replacement. Thus, the absolute growth of body weight of the animals of experimental groups in the main period of the experiment was 3.1 to 7.8% higher than in the control group. At the same time, the heifers of the second experimental group who received Calcium-MAG (table 1) were characterized by a great superiority (7.8%).

Table 1. Age dynamics of body weight of repair heifers, kg (X ± mx).

Parameter	Group: control		Group: 1st experimental		Group: 2nd experimental	
	Body weight	Total gain weight since bitrh	Body weight	Total gain weight since bitrh	Body weight	Total gain weight since bitrh
At birth	31.4±0.71	-	31.0±0.90	-	31.3±0.76	-
at the age of 1 month old	49.7±1.17	18.3±1.21	50.2±1.57	19.2±1.85	53.5±1.43**	22.2±1.63
% by control	100	-	101.0	104.9	107.6	121.3
At the age of 3 months old	96.25±1.69	46.55±1.42	98.4±2.65	48.2±2.70	103.7±1.31**	50.2±1.76*

% by control	100	-	102.2	103.5	107.7	107.8
At the age of 6 months old	166.1±2.51	69.85±2.85	171.7±5.02	73.3±4.76	180.0±2.98**	76.3±1.00*
% by control	100	-	103.4	104.9	108.4	109.2
At the age of 9 months old	227.3±5.89	61.2±5.63	233.8±3.21	62.1±2.93	245.7±3.01*	65.7±1.38
% by control	100	-	102.9	101.4	108.1	105.8
At the age of 12 months old	279.5±5.61	52.2±5.89	288.2±4.45	54.4±4.31	301.4±4.02**	55.7±1.98
% by control	100	-	103.1	104.2	107.8	106.7
at the age of 15 months old	333.6±7.89	54.1±7.65	342.8±7.98	54.6±3.51	358.3±6.78*	56.9±6.85
% by control	100	-	102,8	100,9	107,4	105,2
At the age of 18 months old	392.7±8.12	59.1±5.21	403.0±7.81	60.2±4.89	420.6±7.01*	62.3±2.74
% by control	100	-	102.6	101.8	107.1	105.4
Total	392	361.3	403.0	372.0	420.6	389.3

Note: ** - P≥0.99; * - P≥0.95

The positive effect of calcium gluconates was also observed in further age periods, which led to a statistically significant difference in body weight between control and second experimental group at the age of 18 months by 7.1 (P≥0.99) and 2.6%, respectively.

Analysis of the results of the growth rate of heifer's replacement receiving calcium gluconates showed that the animals of the second experimental group exceeded the average daily weight gain by 10.9 and 2.9% of their analogues from the control group (P≥0.99) and the first experimental group, respectively.

It should be noted that the difference in the intensity of growth between the moment of birth to 3 months of age of heifers was most pronounced, and in the second experimental group it was 822.9 g, which is significantly higher than in control group by 11.6%. The difference in the intensity of growth between the time of birth to 1 month between the animals of the control group and the second experimental group was 27.6% (P≥0.99) in favor of heifers who received Calcium-MAG. The advantage of the herd mate of the first experimental group for this indicator over control animals was 5.0%.

For an objective judgment on the relative growth of experimental animals, the relative growth rate was determined (table 2). It was established that during the time of the study the animals of the control group and the first test group did not differ in the analyzed parameter. In this case, the calves of the second experimental group were superior to their counterparts from the control group and the first experimental group in terms of relative increase by 1.9 and 1.0%, respectively

Table 2. Intensity of growth of experimental animals, X ± mx.

Age period, month	Group					
	control		1st experimental		2nd experimental	
	Average daily weight gain, g	Relative gain, %	Average daily weight gain, g	Relative gain, %	Average daily weight gain, g	Relative gain, %
0 – 1,5	609.3±33.60	45.12±5.21	640.0±34.81	47.3±7.4	740.0±27.89**	52.4±6.9*
% by control	100.0	-	105.0	2.18	127.6	7.28
1,5 - 3	763.1±19.86	63.7±2.60	790.0±23.90	64.8±3.45	822.9±20.73*	63.9±2.75
% by control	100.0	-	103.5	1.1	111.6	0.2
3 - 6	759.2±20.03	53.2±1.91	796.7±45.44	54.3±2.45	829.3±19.24*	53.8±1.46
% by control	100.0	-	104.9	1.1	114.6	-0.5
6 - 9	665.2±32.74	31.1±0.74	675.0±29.87	30.6±0.61	714.1±25.81	30.9±0.53
% by control	100.0		101.5	-0.5	108.9	0.3
9 - 12	567.4±19.33	20.6±0.56	591.3±25.61	20.8±0.48	605.4±20.69	20.9±0.45
% by control	100.0		104.2	0.2	111.2	0.1
12 - 15	588.0±18.74	17.6±0.34	593.5±14.18	17.3±0.21	618.5±16.29	17.25±0.24
% by control	100.0		100.9	-0.3	106.2	-0.05
15 - 18	642.4±16.76	16.2±0.27	654.4±14.23	16.1±0.31	677.2±12.85	16.0±0.19
% by control	100.0		101.9	-0.1	107.4	-0.1

total	658.1±10.54	170.4±	677.6±9.87	171.4±	709.1±8.65**	172.3±
% by control	100.0		102.9	1.0	110.9	1.9

Note: ** - P≥0.99, * - P≥0.95

Sufficient mineral and vitamin nutrition along with others provide the calf with health, optimal bone development, its normal mineralization. It is established that the mineral substances of milk are almost completely absorbed by the calf's organism (by 86-97%). In turn, calcium absorption in calves is reduced to 30% with the addition of cereal concentrates to the milk; in the 6 months of age, calves use calcium and phosphorus rations by 40-50%, while young animals aged 1-2 years - only 25-30% [7,9,13]. Therefore, the search for ways and methods of assimilability improving of any animal nutrition elements has always been and will be relevant.

At the end of the basic period of scientific and economic studies, calves of age 1.5 months old who received Calcium-MAG had an advantage in most of the measurements over the herdmate of the control group. Superiority was found on six out of eight measurements, in particular, in height at the withers and at hips, by 2.7 and 3.2 cm (P≥0.95), oblique body length and chest girth, respectively, by 2.55 and 2.45 cm, chest depth, chest breadth, width in hips by 0.99; 0.58; 0.59 cm. In width of loin and girth of the pastern, the youngest of the second experimental group were slightly inferior to the control animals by 0.94 and 0.1 cm (table 3).

The superiority of the heifers of the second experimental group over the analogues of the control group for indices of superficiality (+0.41), long-nosedness (+0.21%) and thoracic (+0.41) was revealed.

It should be noted that, in general, the animals of both the first and second experimental groups in a number of body articles were superior to the control animals, while the specimens of the second experimental group who received Calcium-MAG showed better results. Such measurements of heifers of the second group, as height at the withers and hips, chest depth, chest breadth were better than the measurements of animals of the control group and the first experimental group. A similar trend was maintained at the age of 3 months old. The advantage in measuring the height at the withers and the height at hips of the calf who received mechanoactivated calcium gluconate, manifested more clearly in comparison with the herdmate of control group (P≥0.95) and the first experimental group.

Table 3. Dimensions and indeces of calf body built, X ± mx.

Parameter	Age, month					
	1,5			3		
	Group					
	control	1st experimental	2nd experimental	control	1st experimental	2nd experimental
Measurement: Height at the withers, cm	78.85 ± 0.79	79.46 ± 1.02	81.55 ± 0.95*	89.17 ± 0.73	90.95 ± 1.10	92.80 ± 0.78*
Height at hips, cm	82.88 ± 0.71	85.46 ± 0.87	86.09 ± 1.06*	94.63 ± 0.83	95.00 ± 1.04	97.25 ± 0.84*
Chest depth, cm	30.15 ± 0.83	31.13 ± 0.63	31.14 ± 1.20	38.21 ± 0.59	39.77 ± 0.58	39.70 ± 0.71
Chest breadth, cm	16.92 ± 0.40	17.04 ± 0.44	17.50 ± 0.42	21.42 ± 0.42	21.73 ± 0.53	21.95 ± 0.54
Width of pelvis in hips, cm	17.96 ± 0.64	19.0 ± 0.56	18.55 ± 0.45	23.46 ± 0.36	23.32 ± 0.58	24.30 ± 0.25
Width of loin, cm	10.85 ± 0.42	10.0 ± 0.44	9.91 ± 0.48	14.79 ± 0.32	14.95 ± 0.33	15.35 ± 0.13
oblique body length, cm	72.04 ± 0.99	75.92 ± 1.45	74.59 ± 1.35	87.88 ± 1.34	88.00 ± 1.51	90.15 ± 1.60
chest girth, cm	83.69 ± 1.18	86.46 ± 1.33	86.14 ± 2.18	102.96 ± 1.27	103.59 ± 1.35	106.90 ± 1.53
girth of the pastern, cm	11.19 ± 0.14	11.83 ± 0.22	11.18 ± 0.17	12.42 ± 0.10	12.55 ± 0.24	12.35 ± 0.17
Indices: Overgrowness	105.17 ±	107.66 ±	105.58 ±	106.14 ±	104.50 ±	104.81 ±

	0.76	1.22	0.50	0.66	0.84	0.62
Long-leggedness	61.68 ± 1.21	60.79 ± 0.80	61.89 ± 1.16	57.17 ± 0.36	56.25 ± 0.52	57.22 ± 0.70
lengthiness	91.48 ± 1.57	95.79 ± 2.51	91.48 ± 1.33	98.52 ± 1.03	96.82 ± 1.61	97.13 ± 1.44
Pelvis-chest	95.68 ± 4.13	90.09 ± 2.16	94.58 ± 1.99	91.57 ± 2.48	93.70 ± 3.20	90.24 ± 1.47
Chest	56.39 ± 1.38	54.79 ± 1.03	56.80 ± 1.99	56.15 ± 1.23	54.63 ± 1.06	55.33 ± 1.15
Blockiness	116.29 ± 1.55	114.08 ± 1.61	115.44 ± 1.76	117.27 ± 1.08	117.88 ± 1.52	118.68 ± 1.09
Massiveness	106.19 ± 1.38	108.98 ± 2.07	105.51 ± 1.70	115.46 ± 1.06	113.96 ± 1.35	115.20 ± 1.35
Boniness	14.20 ± 0.14	14.92 ± 0.32	13.71 ± 0.15	13.93 ± 0.13	13.80 ± 0.23	13.31 ± 0.17

Note: * - P≥0.95

Further observations showed that the height at the withers of animals, both at the age of 12 months old and at the age of 18 months old in the second experimental group was significantly higher than in the control group by 2.7 cm and 3.8 cm, respectively (table 4).

A similar trend was observed in measuring the chest depth. A significant difference in this measurement was established between the animals of the control group and the second experimantal group. At the age of 12 months old, the advantage was 3.6 cm, at the age of 18 months old - 2.6 cm (P≥0.999). For the rest of the body articles, the difference between analyzed groups is not significant.

Table 4. Dimensions and indices of the build of heifers replacement, X ± mx.

Parameter	Age, month					
	12			18		
	Group					
	control	1st experimental	2nd experimental	control	1st experimental	2nd experimental
Measurement: Height at the withers, cm	111.8± 0.91	113.3 ± 1.22	114.5 ± 0.93*	121.8± 0.61	124.4 ± 1.75	125.5 ± 0.72*
Height at hips. cm	116.8± 0.93	117.2 ± 0.84	118.9 ± 0.71	128.4± 1.12	127.7 ± 1.24	129.8 ± 0.93
Chest depth. cm	51.8 ± 1.24	54.6 ± 0.97	55.4 ± 0.61*	58.7 ± 0.43	61.61 ± 0.74	62.3 ± 0.80***
Chest breadth. cm	30.5 ± 0.34	30.5 ± 0.56	32.3 ± 0.75	35.5 ± 0.84	35.61 ± 0.83	36.0 ± 0.62
Width of pelvis in hips. cm	34.8 ± 0.41	34.9 ± 0.74	34.8 ± 0.71	39.8 ± 0.44	40.5 ± 0.73	40.7 ± 0.41
Width of loin. cm	14.0 ± 0.53	14.0 ± 0.32	14.1 ± 0.52	18.3 ± 0.96	17.1± 0.53	18.5 ± 0.42
oblique body length, cm	121,7± 1,21	121,6 ± 1,61	126,8± 1,31	133,5± 1,15	132,4 ± 1,71	135,7 ± 1,80
chest girth, cm	141,6± 1,27	142,6 ± 2,03	144,9 ± 1,61	160,8± 1,86	163,5 ± 2,03	163,8 ± 1,33
girth of the pastern, cm	14,8 ± 0,22	15,3 ± 0,26	15,5 ± 0,23	17,81± 0,22	17,9 ± 0,36	17,7 ± 0,24
Indices: Overgrowness	95.7 ± 0.89	96.7 ± 0.97	96.3 ± 1.13	94.9 ± 0.96	97.4 ± 1.26	96.7 ± 0.99
Long-leggedness	53.7 ± 1.35	51.8 ± 0.69	51.6 ± 0.89	51.8 ± 0.85	50.5 ± 0.55	50.4 ± 0.74
lengthiness	108.9± 2.14	107.3 ± 1.87	110.7 ± 2.01	109.6± 2.26	106.4 ± 1.78	108.1 ± 1.97
Pelvis-chest	87.6 ± 3.02	87.4 ± 2.45	92.8 ± 2.11	89.2 ± 3.18	87.9 ± 2.19	88.5 ± 1.96
Chest	58.9 ± 1.25	55.9 ± 1.63	58.3 ± 1.04	60.5 ± 1.78	57.8 ± 1.27	57.8 ± 1.45

Blockiness	116.4± 1.23	117.3 ± 1.14	114.3 ± 1.56	120.4± 1.63	123.5 ± 1.81	120.7 ± 1.15
Massiveness	126.7± 1.38	125.9 ± 1.40	126.6 ± 1.48	132.0± 1.16	131.4 ± 1.32	130.5 ± 1.06
Boniness	13.2 ± 0.11	13.5 ± 0.16	13.5 ± 0.25	14.6 ± 0.19	14.4 ± 0.27	14.1 ± 0.18

Note: * - P≥0.95

4. Conclusion

The use at an early age of calcium gluconate in the rations of heifers' replacement contributes to their better growth, preserving the aftereffect and in subsequent periods. Introducing of mechanoactivated calcium gluconate into rations has a clear advantage.

Heifers replacement who received Calcium-MAG in the rations were characterized by the best intensity of growth and surpassed their herdmate in height at the withers and chest depth.

5. References

[1] Miglior F *et al* 2005 *J Dairy Sci* **88** 1255-63
[2] Berezkina G Yu 2015 *All-Russian Scientific and Practical Conference. Ministry of Agriculture* 69–72
[3] Volkov Z Ya 2006 *Zootechny* **7** 13–5
[4] Daniel R C W 1983 *Motility of the rumen and abomasums during hypocalcemia 47* 276–80
[5] Ledgard S F *et al* 2004 Effect of calcium supplementation on milk production and hypocalcaemia **66** 69–74
[6] Akhmetov M M *et al* 2016 NMR investigation of conformational changes in calcium gluconate 114–5
[7] Goenko I A *et al* 2016 EPR investigation of the radiation-induced transformation in calcium gluconate 136–7
[8] Han G *et al* 2007 *Nanomedicine* **2(1)** 113–23
[9] Strelkov N S 2008 *Almanac of Clinical Medicine* **17(3)** 66–370
[10] Cohn D V *et al* 1983 *Biosynthesis, processing, and secretion of parathormone and secretory protein*
[11] Salafa O V 2004 Application of nanoparticles in biology and medicine **2(3)**
[12] Stevenson M A 1999 *N Z Vet J.* **47** 53–60
[13] Talmage R V 1970 *Amer. J. Anat.* **129** 467-76
[14] McDougall S 2001 *New Zealand Veterinary Journal* **49** 60–7
[15] Norman A W *et al* 1982 *Endocr Rev.* **3** 331–66