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# Reproductive Ability of Doe-Rabbits and Growth and Preservation of the Offspring by Feeding Sulfur Compounds

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**Abstract**. The use of organic minerals in the form of nanocompounds as a substitute for mineral inorganic salts is promising, but insufficiently studied. Therefore, the purpose of the search was to determine the influence of drinking sulfur citrate and sodium sulfate 14 days before insemination and up to 20th day of lactation on the reproductive capacity of rabbits and the preservation of the offspring up to 40th day of life. The research was carried out on rabbits of the second breed of *Hyla* breed in "Horlytsia". Control group were fed without restriction complete ration granular feed with free access to water. 1st experimental group were fed with the ration of the control group and during the day were watered with sulfur citrate, at the rate of 8 μg S/kg of body weight. II experimental group were fed with the ration of the control group and with water was given sodium sulfate in the amount of 40 mg S/kg of body weight. Additives to rabbits were watered 14 days before insemination and for up to 20 days of lactation. It was found that on the first day of life of young rabbits their number in the I and II experimental groups was respectively higher by 8.5 and 4.2% compared to the control. The number of young rabbits at 20 and 40 days of age in the I and II experimental groups was respectively higher by 10.4 and 4.4% and 14.0 and 4.6% compared to the control group. The weight of rabbits in the nest of the II experimental group at 1, 20 and 40 days of life was respectively higher by 2.8; 6.1 and 7.0%, which is based on the average mass of one rabbit for these periods and amounted to 1.1, respectively; 2.7 and 4.3% compared with animals in the control group. The average amount of milk produced by rabbits of I and II experimental groups was respectively higher by 10.2% and 6.6% per day and for 20 days of the lactation period compared to the control. The preservation of rabbits in the I and II experimental groups was respectively higher by 6.4 and 6.4% and 3.6 and 4.4% at 20 and 40 days of life of young rabbits compared to the control group. The results of the research indicate the possibility of additional use in the ration of rabbits of the addition of sulfur citrate in the amount of 8 μg S/kg of body weight to increase metabolism and reproductive capacity during periods of increased physiological load

**Keywords**: nanotechnologies, lactation, body weight, bioavailability of nutrients



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## INTRODUCTION

Nanotechnologies are used in the feeding of farm animals to improve the bioavailability of nutrients in the organism, to ensure higher taste, consistency, duration of storage of their products [1; 2]. Nanoparticles preserve the unique properties, resulting in significantly improved physical and chemical properties of the used materials, including minerals [3; 4]. Nanotechnology is used in veterinary physiology, for reproduction and genetics of animals, molecular and cell biology, allowing researchers to work with biological components such as DNA, proteins or cells in small amounts, usually nanoliters or picoliters [5]. Complex nanoprograms are used in animal nutrition systems using available tools and methods that have not an influence on animal health and welfare. This technology offers the best solutions for the use and production of livestock products, which can help to reduce costs and improve the quality of the final indicators [6]. The use of nanotechnology is promising in agriculture and food industry, for the diagnosis and prevention of diseases, improving the ability of plants to absorb nutrients, etc [7].

The most important use in this field are nanominerals. They are characterised by a particle size of 1 to 100 nm. Some of them are stable at high temperature and pressure, they are easily digested in the digestive system [8]. This leads to better interaction with other biologically active substances, due to the larger surface area [9]. Some surface active nanomineraly and nanocomponents can bind and remove toxins and pathogens [10; 11]. The researches have shown that the use of nanominerals, such as nanoselenium, nanochrome, nanozinc, can improve the body's resistance to non-communicable diseases and the quality of their products, this is especially true when replacing inorganic salts of mineral elements with organic nanocompounds, which is widely used in the diet of industrial animals [12].

Rabbits are characterised by small body size, greater feed use, rapid growth, quality nutritious meat, early puberty, and high genetic selection potential compared to other farm animals [13]. Sperm quality is the key to successful fertilisation in breeding rabbits and an indicator of the reproductive capacity of rabbits [14]. Gastrointestinal absorption of minerals is influenced by a number of factors, including its chemical form: soluble compounds (oxides, hydroxides, citrates and sulfates) are easily absorbed, but water-insoluble compounds (sulfides) are poorly digested. Minerals in organic forms have a more efficient use in the organism to increase their bioavailability, which leads to improved ejaculate volume, sperm motility, and then male fertility and fertility of rabbits [15]. Several methods have been developed to get nanoparticles [16], including thermal reduction, metal vapor evaporation method, microemulsion technique, mechanical grinding and chemical reduction [17]. However, regardless of the technology of getting nanoparticles, their advantage in use for animals has been noted, although there are not many such researches, especially in rabbit breeding. We conducted research to study the influence of nanocompounds on the organism of rabbits, which showed a positive influence on organism parameters and reproductive capacity [18; 19].

*The purpose of this experiment* was to determine the influence of watering sulfur citrate and sodium sulfate 14 days before insemination and for up to 20 days of lactation on the reproductive capacity of rabbits and the preservation of the offspring up to 40 days of life.

## MATERIALS AND METHODS

The research was carried out on rabbits of the second breed of Hyla breed in "Horlytsia" Ltd., v. Dobryany of Gorodok district of Lviv region, who used organic and inorganic sulfur compounds in physiologically justified amounts in young rabbits in previous research. Females were divided into three groups (control and two experimental), 20 animals in each, selected on the principle of analogues. Controlled rabbits of control group (K) were fed without restriction complete ration granular feed containing 18.5% of crude protein, 8.0% of crude fiber, 3.0% of crude fat and 2250 ME kcal/kg with free access to water. Animals of the I experimental group (D–I) were fed the ration of the control group and during the day were fed sulfur citrate, at the rate of 8 μg S/kg of body weight. Sulfur citrate solution (1.0 g/dm$^3$, pH 1.38) was got from "Nanomaterials and Nanotechnologies" Ltd., Kyiv. Females of experimental group II (D–II) were fed the ration of the control group and with water was given sodium sulfate ($Na_2SO_4$) in the amount of 40 mg S/kg of body weight. Additives to rabbits were watered 14 days before insemination and for up to 20 days of lactation. The experiment lasted 95 days, including the preparatory period of 10 days, the experimental – 85 days. In the preparatory period for 10 days from the beginning of the research and in the experimental period for 20 days of lactation (65 days of supplements watering) in rabbits was determined by fertility by probing for 12 days after insemination, assessed the number and weight and safety of young rabbits in the nest after birth and up to 40 days of age, determined the milk yield of rabbits by the calculation method: to do this, determine the total weight of the nest on the first day of birth and on the 20$^{th}$ day of life, the difference was multiplied by 2.2 – received the estimated amount of milk consumed by young rabbits. It was found that per 1 g of body weight gain is 2.2 g of milk. These methods are described in the handbook [20]. Mathematical processing of research results was developed statistically using the software package Statistica 7.0 software (Stat Soft, Tulsa, USA). Differences between values in the control and experimental groups were determined using ANOVA, where the differences were considered significant at $P<0.05$ (taking into account the Bonferroni error).

## RESULTS AND DISCUSSION

In recent years, the reproductive capacity of rabbits on modern industrial farms has increased due to the use of artificial insemination, hormonal stimulation and selection work. However, there are a number of problems with the supply of minerals and energy during the first and second lactations, which leads to a decrease in the reproductive capacity of rabbits and culling of breeding stock to 80% during the year. Conducting research indicate the importance of providing a complete balanced ration of minerals for young females during lactation, which give a lot of energy to the organism for milk production and embryo development after fertilisation and also continue to increase body weight, which is a physiological process. Therefore, the purpose of our research was to study the influence of drinking sulfur citrate and sodium sulfate on the reproductive capacity and milk yield of rabbits, growth and safety of young rabbits up to 40 days of age. The analysis of table 1 indicates that after insemination of rabbits in all groups, their fertility was the same 100%. The period of pregnancy lasted an average of 31 days, which is within the physiological parameters for this species. Genera in rabbits took place without complications, mainly at night, stillborn rabbits in the nest were not detected. The use of organic and inorganic sulfur compounds in rabbits 14 days before insemination contributed to better fertilisation, which affected the number of offspring in the nest. Thus, on the first day of life of rabbits, their number in the I and II experimental groups was respectively higher by 8.5 and 4.2% compared to the control group. Continuations of research indicate that this feature was noted up to 40 days of life of rabbits. In particular, the number of rabbits at 20 and 40 days of age in the I and II experimental groups was respectively higher by 10.4 and 4.4% and 14.0 (P <0.05) and 4.6% compared to the control group.

***Table 1**. The influence of sulfur citrate and sodium sulfate on the reproductive capacity of rabbits (M±m, n=20)*

| Group | Fertility, % | Number of born rabbits, % | | Number of rabbits in the nest | | |
|---|---|---|---|---|---|---|
| | | Living | Dead | 1 day | 20 day | 40 day |
| K | 100 | 100 | – | 7.0±0.3 | 6.7±0.3 | 6.4±0.1 |
| % | | | | 100 | 100 | 100 |
| D–I | 100 | 100 | – | 7.6±0.4 | 7.4±0.4 | 7.3±0.2* |
| % | | | | 108.5 | 110.4 | 114.0 |
| D–II | 100 | 100 | – | 7.3±0.6 | 7.0±0.4 | 6.7±0.2 |
| % | | | | 104.2 | 104.4 | 104.6 |

***Note**: statistically significant differences were taken into account compared with the control group: * – P<0.05, ** – P<0.01, *** – P<0.001; the selections were compared within one line (taking into account Bonferroni correction)*

In the biosphere, the physical, chemical and biological properties of matter are determined by physicochemical phenomena. However, only the size of the substance reduces the action of these variable forces. The size of the substance acquires new physicochemical characteristics. Nanoparticles remain protected from various types of bioactive agents and reactions, such as oxidation, enzymatic or chemical interaction with other molecules. This is due to the active component of nanoparticles, increasing their stability. Therefore, in our opinion, the results got may depend on the used sulfur compound, which has unique properties in the organism that has an influence on the stimulating factors of metabolism.

The analysis was performed on the results of growth and development of rabbits organism showed that the watering of sulfur compounds to rabbits of the second round had an influence on the fetal and postembryonic period of their development (Table 2). In particular, the investigated weight of rabbits that were in the nest of the I experimental group at 1, 20 and 40 days of their lives was respectively higher by 10.0; 20.4% (P<0.05) and 11.9% (P<0.05) compared with the control group. The got results correlated with the indication of average weight of one rabbit in the nest, which on 1, 20 and 40 days exceeded 1.8; 5.2 and 6.4% (P<0.05) of rabbits included in the control. The weight of rabbits in the nest of the II experimental group at 1, 20 and 40 days of life was respectively higher by 2.8; 6.1 and 7.0% (P<0.05), which is justified by the average weight of one rabbit for these periods and amounted to 1.1, respectively; 2.7 and 4.3% compared with animals in the control group.

***Table 2**. The influence of sulfur citrate and sodium sulfate on the growth of rabbits during lactation (M±m, n=30-34)*

| Group | Mass of rabbits in the nest, g (age of life) | | | Average weight of one rabbit, g (age of life) | | |
|---|---|---|---|---|---|---|
| | 1 | 20 | 40 | 1 | 20 | 40 |
| K | 418.9±25.0 | 2072.2±63.2 | 5519.1±38.8 | 60.2±0.31 | 321.1±4.11 | 903.7±14.8 |
| % | 100 | 100 | 100 | 100 | 100 | 100 |
| D–I | 461.1±28.6 | 2495.8±143.0* | 6180.4±216.0* | 61.3±0.29* | 338.0±5.29* | 962.3±9.04* |
| % | 110.0 | 120.4 | 111.9 | 101.8 | 105.2 | 106.4 |
| D–II | 431.0±22.4 | 2199.5±72.1 | 5909.1±147.8* | 60.9±0.15 | 329.9±3.50 | 943.2±8.6 |
| % | 102.8 | 106.1 | 107.0 | 101.1 | 102.7 | 104.3 |

***Note**: statistically significant differences were taken into account compared with the control group: * – P<0.05, ** – P<0.01, *** – P<0.001; the selections were compared within one line (taking into account Bonferroni correction)*

The got results may indicate that sulfur citrate in the consumed amount, better absorbed in the digestive tract of rabbits and young rabbits up to 40 days of age, which contributed to better bioavailability of nutrients, including sulfur and its positive influence on the growth and development of young rabbits, while the watering of sodium sulfate was marked by less pronounced investigated indicators of their organism compared with the control. Investigations have shown that the young rabbits of the two experimental groups had a higher nest weight and one animal at 1, 20 and 40 days of lactation compared to the control. Suckling rabbits have high energy needs and are characterised by low thermal insulation in the nest, if the temperature is low then the milk consumed is not absorbed by the organism. Therefore, the preservation and development of young rabbits in the nest is completely related to the quantity and quality of breast milk and offspring. The use of organic and inorganic sulfur compounds in rabbits of the experimental groups was marked by a greater amount of produced milk (Table 3).

***Table 3**. Milk yield of rabbits and preservation of the offspring during watering of sulfur citrate and sodium sulfate (M±m, n=20)*

| Group | Milk production of rabbits, g | | % Preservation of the offspring | |
|---|---|---|---|---|
| | Per day | For 20 days | 20th day | 40th day |
| K<br>% | 186.1 ± 8.22<br>100 | 3723.9±190.1<br>100 | 91.3 | 88.2 |
| D–I<br>% | 205.3 ± 12.5*<br>110.2 | 4106.2±276.8*<br>110.2 | 97.2<br>6.4 | 93.9<br>6.4 |
| D–II<br>% | 198.5 ± 6.14<br>106.6 | 3970.1±123.0<br>106.6 | 94.6<br>3.6 | 92.1<br>4.4 |

***Note:** statistically significant differences were taken into account compared with the control group: * – P<0.05, ** – P<0.01, *** – P<0.001; the selections were compared within one line (taking into account Bonferroni correction)*

In particular, the average amount of produced milk by rabbits of experimental group I was higher by 10.2% (P <0.05) per day and for 20 days of the lactation period compared to the control. The got results of the research may indicate a general activating influence of sulfur nan compounds on metabolism in the organism and the process of metabolism in the mammary gland of rabbits, which was more pronounced under the action of sulfur citrate. Slightly different results were got in rabbits of experimental group II, which received sodium sulfate with water, the amount of milk secreted per day and during 20 days of lactation was higher by 6.6% compared with the control group of animals, but these results were unlikely. The results of the preservation of young animals during the search period (40 days of life from birth) in the experimental groups were slightly higher compared to the control. The research by domestic and foreign authors have shown that the quantity and quality of milk from rabbits has an influence on the safety of rabbits during lactation. The results confirming these generalisations were got due to the conducted researches. Thus, the safety of rabbits in the first experimental group was respectively higher by 6.4% at 20 and 40 days of life of rabbits compared with the control group. Watering of the inorganic sulfur compound was marked by less pronounced results of preservation of young animals. In particular, in the second experimental group, the survival of rabbits at 20 and 40 days of life was respectively higher by 3.6 and 4.4% compared with the control. The obtained results of the experiment may indicate more pronounced correlations between milk yield and productivity and preservation of young rabbits in the suckling period under the action of the organic compound sulfur citrate.

## CONCLUSIONS

Rabbits watering 14 days before insemination and for up to 20 days of lactation of sulfur citrate in the amount of 8 μg S/g of body weight, was markedly higher (P<0.05) number of rabbits per 40 days of life, greater weight of the nest and one rabbit (P<0.05) for 20 and 40 days from birth, more produced milk per day and 2 days (P<0.05) and higher rates of preservation of 6.4% for 40 days of life compared with the control group. The use of sodium sulfate in the ration of rabbits in the amount of 40 mg S/kg of body weight, contributed to higher nest weight at 40th day of age (P<0.05) and a tendency to more milk from rabbits and retention of offspring up to 40 days of age compared to control.

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# Репродуктивна здатність кролематок та ріст і збереженість молодняку за випоювання сполук сульфуру

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**Анотація**. Застосування органічних мінеральних речовин у вигляді наносполук, як заміни мінеральних неорганічних солей є перспективним, але недостатньо вивченим. Тому метою дослідження було з'ясувати вплив випоювання сульфуру цитрату та сульфату натрію за 14 діб до осіменіння і упродовж до 20 доби лактації на репродуктивну здатність кролематок та збереженість приплоду до 40 доби життя. Дослідження проведені на кролематках другого окролу породи *Hyla* у ТзОВ «Горлиця». Контрольній групі згодовували без обмеження повнораціонний гранульований комбікорм з вільним доступом до води. Тваринам І дослідної групи згодовували корми раціону контрольної групи і впродовж доби випоювали сульфуру цитрат, з розрахунку 8 мкг S/кг маси тіла. ІІ дослідній групі згодовували корми раціону контрольної групи і з водою задавали сульфат натрію в кількості 40 мг S/кг маси тіла. Встановлено, що на першу добу життя кроленят їхня кількість у І і ІІ дослідних групах була відповідно вищою на 8,5 і 4,2 % порівняно до контролю. Кількість кроленят на 20 і 40 доби життя у І і ІІ дослідних групах була відповідно вищою на 10,4 і 4,4 % та 14,0 і 4,6 % порівняно до контрольної групи. Маса кроленят у гнізді ІІ дослідної групи на 1, 20 і 40 доби життя була відповідно вищою на 2,8; 6,1 і 7,0 %, що обґрунтовується середньою масою одного кроленяти за вказаними періодами і становила відповідно 1,1; 2,7 і 4,3 % порівняно з тваринами контрольної групи. Середня кількість продукованого молока кролематок І і ІІ дослідних груп була відповідно вищою на 10,2 і 6,6 % за добу та за 20 діб лактаційного періоду порівняно з контролем. Збереженість кроленят у І і ІІ дослідних групах була відповідно вищою на 6,4 і 6,4 % та 3,6 і 4,4 % на 20 і 40 доби життя кроленят порівняно з контрольною групою. Отримані результати дослідження вказують на перспективу додаткового використання у раціоні кролематок добавки сульфуру цитрату в кількості 8 мкг S/кг маси для підвищення обміну речовин та репродуктивної здатності у період підвищеного фізіологічного навантаження

**Ключові слова**: нанотехнології, лактація, маса тіла, біодоступність поживних речовин