Optimization of feeding conditions for dairy goats in order to increase their productivity

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Abstract. Currently, goat farming becomes a perspective sector focused on production of goat’s milk and its products. Volume of milk produced by goats is determined by three factors: genetic heredity; environmental conditions, animal welfare and care conditions; feeding quality. In order to increase the productivity of dairy goats, it is necessary to improve and optimize feeding rates as the feeding is an essential factor defining the development of milk productivity. Sound feeding practices result in goats producing more than 1000 kg of milk containing up to 4.5% fat. This practice-oriented research is based on the decision to use the information and analytical systems “RATIONS” in order to calculate balanced rations for adequate nutrition of dairy goats. Particular attention was given to introduction of feeding rates adjusted to fulfill their nutrient requirements of Saanen goats in North-West District of Russia.

1. Introduction
Currently, goat farming becomes a perspective sector of Russian market focused on production of goat milk and its products. The world practice of development of livestock businesses as well as numerous works of such researchers as M.T. Moroz et al. [1], D. Reczynska et al. [2], H.W. Neave et al. [3], C.N Marcos et al. [4], M. Palma et al. [5] proved that, in order to increase the productivity of dairy goats, it is necessary to optimize their feeding and housing conditions. The volume of milk produced by goats is determined by three factors: genetic heredity; environmental conditions, animal welfare and care conditions; feeding quality.

For dairy goats, as well as for the whole livestock sector in general, two housing systems are applied:
- the loose housing: animals are allowed to move freely in sections, yards of under shelter;
- the stall barn system: each animal is kept in a separate little cubicle or tied in a stable.

Feeding behavior of dairy goats housed using the closed housing system attracts increasing attention. In the course of research, it was determined that dry matter intake of Saanen goats, as well as their productivity, increases when feeding bunks for hay, grain, mineral supplements and water bowls are placed on a concrete platform some distance away from the cubicles. When the feeding rates are well adjusted, the animals demonstrate optimal development, good health and high milk productivity [1].

Dairy goats are ruminants and, for this reason, they need bulk feed in their rations; at the same time, the abundance of concentrated feed is undesirable for them. Due to this fact, the amount of nutrients, micro- and macroelements, and the vitamins supporting milk productivity on genetic level must be balanced in the ration of dairy goats.
For this reason, it is necessary to use bulk feed: hay, silage or haylage, dried beet pulp containing dietary fiber, concentrated fodder, root crops, mineral additives for sustaining productivity and animal health.

The grain fed should be rolled or crushed, but not ground, as the flour seals mucous cells of digestive organs. It is not recommended to use feeds containing urea.

For goats, it is always necessary to develop a “target-focused” premix, the content of which depends on the vitamins and mineral supplements in feeds included into the ration.

Several researches [1, 2, 4, 6] state that the content of nutrients and bioactive substances in rations of animals, including dairy goats, must be compliant with the rates of their requirements.

It becomes much simpler to face the challenge of calculating and balancing feed rations, as well as establishing adequate feeding for dairy goats, if one uses information and analytical systems IAS “RATIONS”. Advanced version of software and hardware complex for calculation of feeding rations using the automated system allows one to solve various problems of animal feeding. IAS “RATIONS” software was developed by OOO RC “PLINOR”.

The calculation of feed rations is presented in two variants. The first variant is the calculation of actual ration used in an agricultural enterprise. This is the easiest approach. The second variant is the optimization calculation obtained as the result of search for feeding conditions necessary for maintaining the given productivity level, preservation of health and longevity of animals.

A full analysis of rations is provided for both approaches together with the recommendations on the necessary supplements and premixes. Report forms include:

- “Composition of a ration with premix”. A ration composition is supplemented with a mineral feed “Premix” calculated for this particular ration. This form contains the composition of a mineral feed calculated for this ration.
- “Feeding requirements”. This report form includes feed ration, its value, feeding requirements for a particular stock and for a given period of calculation. The number of animal units and days is assigned in “Ration reports” window before printing.
- “Ration nutritive value”. This form includes: a list of standardized parameters, their content in a ration, deviations from the norm in absolute and relative values.
- “Ration structure”. The structure of a ration is presented per metabolic energy and dry matter. Deviations from the structure are presented based on the parameter assigned before the calculation of the ration in a “Structure” tab of the “Ration” window.
- “Ratios”. This form contains the data about the main ratios of nutrients and mineral elements.
- “Zootechnical parameters”. This form contains analysis of feeding adequacy, consumption of feeds for production, costs and revenue.

Previously, we introduced a system-situational approach for identification of the main factors affecting the efficiency and quality of production processes. The authors are convinced that the development of feeding program for dairy goats combines science and art of feeding in one process. Agricultural professionals need effective and convenient for practical application tools and methods allowing one to calculate feed rations for dairy goats on an on-going basis based on their productivity and average daily gain. It is necessary to solve the problems of adjusting the structure of feed rations depending on annual periodicity, climate and environmental conditions of dairy goat keeping, which make this research particularly relevant.

At the same time, several authors [7, 8, 9, 10, 11, 12] confirm that there is a need in professionals of a new generation as the lack of sufficient qualification is the main hinderance in the way of transition to the new technological structure, introduction of innovations in agricultural production including the active use of information and analytical systems in order to compile feed rations for dairy goats. Authors think that improvement of education quality, training highly competitive specialists for the modern labor
market of the regions can be obtained only through combined integrated efforts of agricultural education, employers, governing bodies of agro-industrial complex.

2. Objects and methods of research
The factors of development of adequate feeding for dairy goats and adjusted rates for calculation of feed rations are the object of this research.

In this research work, the authors used general scientific approaches such as synthesis and analysis as well as methods of statistical observation, dynamic comparison, structural analysis, correlation and regression analysis, graphical and tabular presentation of empirical information. Theoretical analysis of sources – publications of foreign authors [2; 3; 4; 5; 6; 10, 12] – was used as one of the research methods. This allowed us to improve and optimize feeding rates as the feeding is an essential factor defining the development of milk productivity.

3. Results and discussion
In order to increase the productivity of dairy goats, it is necessary to improve and optimize the feeding rates as the feeding is an essential factor defining the development of milk productivity. The rates developed for dairy goats by the authors in the course of this research are presented in table 1 and table 2.

Table 1. Feeding rates for dairy goats.

| Liveweight, kg | Milk yield, kg | Dry matter, kg | Metabolic energy, MJ | Crude protein, g | Fiber, g | Sugar, g | Starch, g |
|---------------|---------------|---------------|----------------------|-----------------|---------|---------|----------|
| 50            | 3             | 2.57          | 25.7                 | 322             | 475     | 231     | 359      |
|               | 4             | 3.09          | 30.9                 | 399             | 547     | 290     | 463      |
|               | 5             | 3.61          | 36.1                 | 476             | 640     | 340     | 542      |
|               | 6             | 4.14          | 41.4                 | 553             | 732     | 389     | 621      |
| 60            | 3             | 2.71          | 27.1                 | 336             | 502     | 244     | 380      |
|               | 4             | 3.24          | 32.4                 | 413             | 573     | 304     | 485      |
|               | 5             | 3.76          | 37.6                 | 490             | 665     | 353     | 564      |
|               | 6             | 4.28          | 42.8                 | 567             | 758     | 403     | 643      |
| 70            | 3             | 2.85          | 28.5                 | 349             | 528     | 257     | 399      |
|               | 4             | 3.38          | 33.8                 | 426             | 598     | 317     | 506      |
|               | 5             | 3.90          | 39.0                 | 503             | 690     | 367     | 585      |
|               | 6             | 4.42          | 44.2                 | 580             | 783     | 416     | 664      |
| 80            | 3             | 2.99          | 29.9                 | 361             | 552     | 269     | 418      |
|               | 4             | 3.51          | 35.1                 | 438             | 621     | 330     | 527      |
|               | 5             | 4.03          | 40.3                 | 515             | 714     | 379     | 605      |
|               | 6             | 4.56          | 45.6                 | 592             | 807     | 429     | 684      |

The content of metabolic energy (MJ) depends on the presence of nutrients in rations which is essential for productivity of dairy goats. Energy deficiency hinders the growth of a kid, slows down puberty, decreases fertility and milk productivity. Energy limitations can be caused by malassimilation of the feed and a low quality of the ration in general.

Proteins are nutrients essential for animal body metabolism. Proteins consist of amino acids that are the building blocks for body cells. That is the reason why proteins are vital for growth, reproduction and
milk productivity. Proteins help animals stay active, support fetal growth during advanced pregnancy, sustain milk productivity and fulfill energy requirements.

It is worth noting that the energy content and activity of cicatricial microflora in a ration are defined by the optimum quantity of carbohydrates. At the same time, insufficient quantity of carbohydrates in a ration can cause metabolic disturbance. The main role of carbohydrates is to affect the efficiency of making use of nutrients in a ration. This is due to the fact that the carbohydrates provide cicatricial microflora with the energy and at the same time, affect digestion and the use of nutrients significantly.

Bulk feeds are the main source of fiber. It can be used by the animal body only after it is broken down by cicatricial microflora. Bulk feed fiber is covered with lignin, inert substance that decreases digestibility of fiber. Grasses in early vegetative stages contain insignificant amount of lignin; the amount of lignin in grasses in later vegetative stages is much higher.

Sugar and starch are nonstructural carbohydrates. They are located inside the cell and are digested better than structural carbohydrates. Plant cells contain sugars; there are more of them in grasses in early vegetative stages. When herbaceous feeds are ensiled, almost all the sugar turns into VFA. The level of sugar in herbaceous feeds indicates the quality of forage preparation which depends on the time and process of harvesting. Generally, the sugar level in rations of goats is almost always lower than standard. The main sugar source can be found in root crops and molasses.

Mineral requirements of dairy goats are presented in table 2.

Table 2. The mineral requirements of dairy goats.

| Liveweight, kg | Milk yield, kg | Dry matter, kg | Ca, g | P, g | Mg, g | Na, g | Cu, mg | J, mg | Zn, mg | Co, mg |
|---------------|---------------|----------------|-------|------|-------|-------|--------|-------|--------|--------|
| 50            | 3             | 2.57           | 13.3  | 9.4  | 7.18  | 6.41  | 23.34  | 0.82  | 128.3  | 2.05   |
|               | 4             | 3.09           | 16.3  | 11.6 | 8.65  | 7.72  | 28.11  | 0.99  | 154.5  | 2.47   |
|               | 5             | 3.61           | 19.4  | 13.8 | 10.12 | 9.03  | 32.88  | 1.16  | 180.7  | 2.89   |
|               | 6             | 4.14           | 22.5  | 16.0 | 11.59 | 10.34 | 37.65  | 1.32  | 206.9  | 3.31   |
| 60            | 3             | 2.71           | 13.3  | 9.4  | 7.59  | 6.78  | 24.67  | 0.87  | 135.6  | 2.17   |
|               | 4             | 3.24           | 16.3  | 11.6 | 9.06  | 8.09  | 29.44  | 1.04  | 161.8  | 2.59   |
|               | 5             | 3.76           | 19.4  | 13.8 | 10.53 | 9.40  | 34.21  | 1.20  | 188.0  | 3.01   |
|               | 6             | 4.28           | 22.5  | 16.0 | 11.99 | 10.71 | 38.98  | 1.37  | 214.2  | 3.43   |
| 70            | 3             | 2.85           | 14.3  | 10.1 | 7.99  | 7.13  | 25.96  | 0.91  | 142.6  | 2.28   |
|               | 4             | 3.38           | 17.3  | 12.3 | 9.45  | 8.44  | 30.73  | 1.08  | 168.8  | 2.70   |
|               | 5             | 3.90           | 20.4  | 14.5 | 10.92 | 9.75  | 35.49  | 1.25  | 195.0  | 3.12   |
|               | 6             | 4.42           | 23.5  | 16.7 | 12.39 | 11.06 | 40.26  | 1.42  | 221.2  | 3.54   |
| 80            | 3             | 2.99           | 14.3  | 10.1 | 8.36  | 7.47  | 27.18  | 0.96  | 149.3  | 2.39   |
|               | 4             | 3.51           | 17.3  | 12.3 | 9.83  | 8.78  | 31.94  | 1.12  | 175.5  | 2.81   |
|               | 5             | 4.03           | 20.4  | 14.5 | 11.30 | 10.09 | 36.71  | 1.29  | 201.7  | 3.23   |
|               | 6             | 4.56           | 23.5  | 16.7 | 12.76 | 11.40 | 41.48  | 1.46  | 227.9  | 3.65   |

Calcium is the main material for building bone tissue in a goat’s body. It is found in all the body and milk cells; it is involved in irritability of muscular and nervous tissues, reaction control and blood clotting ability. At the same time, calcium accessibility depends on the presence of vitamin D, the insufficient presence of which decreases calcium accessibility.

Phosphorus is needed in rations of goats for normal vital activity of microflora of forestomach. Continuous insufficient presence of phosphorus in a ration causes such diseases as osteomalacia, osteoporosis, aphosphorosis accompanied by nutritional infertility.

Cuprum is essential for metabolism of dairy goats. Insufficient amount of cuprum in the body of an animal causes loss of appetite, weight loss, low hemoglobin level, decrease in the number of red blood
cells. Goats demonstrate liveweight loss, injury of internal organs, acardiotrophia and anemia. Such animals do not go in heat or the signs of it are weak; miscarriages are common. Kids are born weak; their growth rates are slow and quite many of them they die during the first days of their life demonstrating the signs of hypochromic anemia.

Magnesium is also essential for the body of goats as it takes part in protein synthesis and carbohydrate metabolism. Magnesium activates almost 50 enzymes and is found in bones and soft tissues. Insufficient amount of magnesium causes goats to demonstrate nervous excitement, shiver, twitching of face muscles, staggering, convulsions.

Zinc in a ration improves reproduction in a stock. Zinc deficiency causes parakeratosis manifesting itself in appearance of hairless spots on the skin, hyperkeratosis and scaling of the neck, hindhead and chest skin.

Iodine is a constituent part (65%) of a thyroid hormone thyroxin. Iodine deficiency in feeds of dairy goats impairs the thyroid activity which can lead to decreased secretion of milk and milk fat.

When the premixes containing the deficient elements are introduced into the ration, positive effect does not manifest itself immediately. Usually, the first signs of general well-being mend, improvement of appetite are noticed 4-5 days after introduction of specific “target-focused” premix that causes significant changes in metabolism

4. Conclusion

The research showed that dairy goat breeding is actively developing in farms and agricultural enterprises as this branch of livestock business allows farmers to achieve a high milk productivity and brings profit. Dairy goats possess significant abilities to mobilize tissue energy to support milk productivity. However, it is necessary to improve feeding in order to recover liveweight.

Tissue energy mobilization should be controlled during pregnancy in order to support the milk production throughout early lactation. There is a fair possibility to minimize production expenses using by-products and non-conventional feed resources containing fiber.

Dry matter intake increase after kidding helps to avoid disturbance in metabolism, minimize liveweight loss and improve fertility. Dry matter intake can decrease to up to 3-5% if moisture content of feed mixture in a ration is over 45%.

References
[1] Moroz M T, Mark I A and Samorukov V I 2019 Adapting needs of young cattle to the real conditions of feeding Izvestiya St. Petersburg State Agrarian University 3 (56) 93–9
[2] Reczynska D, Witek B, Jarczak J, Czpopowicz M, Mickiewicz M, Kaba J, Zwierczowski L and Bagnicka E 2019 The impact of organic vs. inorganic selenium on dairy goat productivity and expression of selected genes in milk somatic cells Journal of dairy research 86 (1) 48–54
[3] Neave H W, von Keyserlingk M A, G, Weary D M and Zobel G 2018 Feed intake and behavior of dairy goats when offered an elevated feed bunk Journal of dairy science 101 (4) 3303–10
[4] Marcos C N, Carro M D, Yepes J E F, Haro A, Romero-Huelva M and Molina-Alcaide E 2020 Effects of agroindustrial by-product supplementation on dairy goat milk characteristics, nutrient utilization, ruminal fermentation, and methane production Journal of dairy science 103 (2) 1472–83
[5] Palma M, Alves S P, Hernandez-Castellano L E, Capote J, Castro N, Arguello A, Matzapatakis M, Bessa R J B and de Almeida A M 2017 Mammary gland and milk fatty acid composition of two dairy goat breeds under feed-restriction Journal of dairy research 84 (3) 264–71
[6] Abdushaeva Ya M, Shtro O V and Vetkina A V 2019 Vegetable Resources Monitoring as the Region’s Raw Material Base Effective Management Tool vol LXXVII (Veliky Novgorod: Future Academy) 407–13
[7] Kozina A M and Semkiv L P 2019 Main Approaches to the Use of Digital Intellectual Technologies in Agro-Industrial Complex vol 13 (Kazan: Astor i Ya) 53–8
[8] Moroz M T and Vasilyeva O P 2018 Competitive advantage of agro-industrial complex
enterprises through advanced training of livestock business professionals with the use of information technology. Rationing and Payment in Agriculture 12 44–8

[9] Kozina A M and Semkiv L P 2016 Human Resources in the Management of Milk Production. Effective Management in Dairy Cattle Breeding is a Condition for the Competitiveness of Milk Production (Velikiy Novgorod: NovSU) 26–7

[10] Klochkova E, Evdokimov K, Klochkov Yu and Samorukov V 2018 Methodology for Reducing Risk of Underperformance of Personnel Functions (Jelgava) 1213–22

[11] Kozina A M, Guleichick A I and Semkiv L P 2017 Fresh approaches to reserves preparation of managerial personnel for agriculture of Novgorod region Problems of Innovativ Development of Agro-Industrial Complex: Staff, Technologies, Efficiency 11 73–7

[12] Kozina A M, Semkiv L P and Grishakina N I 2019 Methodological Approaches in Improving Human Resources Potential of Agro-Industrial Complex vol LXXVII (Veliky Novgorod: Future Academy) 391–7