Young sheep of Romanov breed: productivity and biological features at different levels of energy and protein in the diet

V G Dvalishvili¹, A S Khodov², I F Gorlov³, E Yu Anisimova³, N I Mosolova³ and N V Filipov³

¹ L.K. Ernst Federal Science Center for Animal Husbandry (Dubrovitsy 60, Podolsk Municipal District, Moscow Region, 142132, Russia
² Farm “Pokrov” Paris Commune street, 41, Tver region, Zubtsov, 172332, Russia
³ Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production, 6, Rokossovskogo street, Volgograd, 400131, Russian Federation

E-mail: dvalivig@mail.ru

Abstract. The experiment was performed on two groups of Romanov sheep at the age of from 3 to 10 months under different rearing and fattening conditions at the “Pokrov” sheep farm in the Tver region. An increase in metabolic energy and crude protein in the diets of animals from 3 to 7 months of age led to an increase in the growth intensity of the body weight in Group II. The live weight of rams at the age of 7 months was greater by 5.79 kg or 17.75% in Group II than in Group I, and the daily gain increased from 138 g to 186 g. In terms of the daily gain, the difference at this age was 45 g or 32.37%. According to the slaughter results, the pre-slaughter weight of the rams in Group II increased by 9.73 kg or 22.3% compared to Group I; the hot carcass weight was greater by 5.08 kg or 25.5%; the slaughter weight by 6.4 kg or 31.1%; and the slaughter yield increased from 47.3% to 50.7%, or by 3.4 absolute percent. The histological studies of the longissimus muscle showed, that in Group II, the diameter of muscle fibers increased by 4.3 μm or 15.7%, the diameter of fat cells by 6.2 μm or 10.4%; and the numbers of muscle and fat cells per 1 cm² of the longissimus muscle increased and amounted to 5.6 and 28.6%, respectively. The width of the connective tissue decreased by 5.2 μm or 14.7%. The difference in the amounts of wool shorn—original and clean fiber—was 0.27 and 0.20 kg or 20.1% and 21.1% in favor of Group II animals with an increased level of energy and protein in their diets. The histological studies of skin showed, that the total skin of rams in Group II (at intensive feeding) was thicker by 523 μm or 22.6% than in Group I, with the pilar layer being thicker by 231 μm or 15.1%. The thickness of the reticular layer increased by 290.5 μm or 38.8% in young animals of Group II. The 3-7 month old Romanov rams with the live weight of 16-38 kg and 186 g of the daily body weight gain had requirements for 1.45 kg of dry matter (DM), 1.50 energetic feed units (EFU) of exchange energy, and 186 g of crude protein per 1 head a day at a cost of 7.8 kg of DM, 8.06 EFU of metabolic energy, and 988 g of crude protein per 1 kg of increase.

1. Introduction

The Romanov sheep – one of the unique breeds – has been bred for a long time, since the pre-revolutionary Russia [1, 2, 3]. The peculiarity of the Romanov sheep is its multiple lambing, polyestricity, and unsurpassed fur coat properties [4, 5, 6]. On average, the fertility of Romanov ewes is
280-300 lambs per 100 head of ewes. The Romanov sheep can be remated throughout the year, though in the summer period (due to high air temperature), the ewes’ mating mood is somewhat reduced.

The high fur coat properties of the Romanov sheepskin is noted for a thin strong pelt and a special structure of hair. Unlike sheep of other coarse-wooled breeds, Romanov sheep’s down fiber outgrows the ordinary hair; their optimal ratio is 1:4–1:7, which determines special thermal properties of the Romanov sheepskin and lightness of dressed sheepskins. Moreover, the optimal ratio between the original hairs and fur fiber gives the sheepskins a beautiful, bluish tint.

Along with the outstanding properties of the Romanov sheep breed, the properties such as vitality, strength of the constitution, and meat forms need to be improved [7, 8], which can be achieved both by crossing with rams that possess outstanding meat properties and by appropriate feeding conditions [9, 10, 11, 12, 13]. For intensive rearing and fattening of young Romanov sheep, it is necessary to develop appropriate norms of energy and protein nutrition and feeding rations. We dealt with these issues in our work.

The purpose of the research was comparative studying the effectiveness of feed for young sheep under different feeding conditions and specifying the norms of metabolic energy and crude protein for growing Romanov rams at the age of 3 to 10 months at intensive rearing and fattening.

2. Research methods and materials
The experiment was performed on a sheep farm of a pedigree reproducer “Pokrov,” farm enterprise, LLC, Zubtsovsky district, the Tver region. After weaning lambs at the age of three months, 2 groups of rams were formed from twin litters, 15 head each. The lambs were analogous in age, type of birth, and body weight. The rams in Group I (control) consumed fodder that was compliant with the ration adopted in the farm and calculated to obtain moderate gains; rams in Group II (test) received feed that was higher in metabolic energy and crude protein by 20-25% compared to Group I and designed for intensive growing and fattening [14]. Table 1 shows the design of the experiment.

| Group | Breed  | Sex  | Number head | Age, months beginning of the experiment | Live weight at the beginning of the experiment, kg | Feeding conditions                                      |
|-------|--------|------|-------------|----------------------------------------|--------------------------------------------------|--------------------------------------------------------|
| I     | Romanov | male | 15          | 3–10                                   | 16.0                                             | Household diet (moderate rearing)                       |
| II    | Romanov | male | 15          | 3–10                                   | 16.0                                             | Intensive growing and fattening according to VIZh standards |

During the experiment, the consumed feed was registered every 10 days by weighing the given feed and residues. The rams were individually weighed monthly, which was followed by the calculation of the average daily live weight gain. At the age of 5 months, we conducted an experiment to determine the digestibility of nutrients in diets according to the VIZh method and a control slaughter according to the generally accepted method. The morphological composition of carcasses, chemical composition of meat, histology of the longissimus muscle and skin [14], and blood biochemistry were studied. We also calculated the metabolic energy, dry matter, and crude protein spent per 1 kg of the body weight gain of rams at the age of 3-7 and 7-10 months.

3. Results and discussion
Based on the values recommended by the detailed feeding rates for young Romanov sheep and adjusted by scientists at the VIZh laboratory of breeding and feeding of sheep [18, 19, 20], we developed feeding rations for rearing and fattening young Romanov sheep at the age from 3 to 7 and from 7 to 10 months. The diets actually consumed are shown in table 2. The animals were fed in groups twice a day, i.e. in the morning and in the evening.
Table 2 shows that the rams in both groups consumed the same amount of roughage fodder – 0.3 kg of cereal-legume hay and 1.1 kg of the same haylage. Increased energy and protein nutrition of the diets in Group II was achieved by increasing the content of compound feed from 0.40 kg to 0.67 kg or by 0.27 kg (+67.5%). In this regard, the energy nutritional value of the ration in Group II increased by 0.32 EFU and by 37 g of crude protein or by 27.1 and 25.2%, respectively; the energy concentration in 1 kg of dry matter of the diet increased from 9.75 MJ to 10.34 MJ of gross digestible energy (GDE).

**Table 2.** Rations of young Romanov sheep from 3 to 10 months of age (actually consumed feed).

| Composition and nutritional value | Parameter          | Age, from 3 to 7 months |
|----------------------------------|--------------------|
|                                  | Weight, kg | Energetic feed unit (EFU) | Dry matter, kg | Crude protein, g | Diet structure for DM, % |
| Cereal-legume hay                | 0.3        | 0.20                        | 0.26           | 30               |
| Cereal-legume haylage            | 1.1        | 0.50                        | 0.61           | 60               |
| Hay + haylage (rough)            | 1.40       | 0.70                        | 0.85           | 90               | 71.4                      |
| Compound feed                    | 0.40       | 0.48                        | 0.34           | 57               | 28.6                      |
| Total                            | –          | 1.18                        | 1.19           | 147              | 100                       |
| GDE in 1 kg of dry matter, MJ    | 9.75       |                             |                |                  |
| Group I                          |            |                             |                |                  |
| Cereal-legume hay                | 0.6        | 0.40                        | 0.49           | 60               |
| Cereal-legume haylage            | 1.5        | 0.67                        | 0.80           | 80               |
| Compound feed                    | 0.67       | 0.78                        | 0.55           | 90               | 30                        |
| Hay + haylage (rough)            | 2.1        | 1.07                        | 1.29           | 140              | 70                        |
| Total                            | –          | 1.85                        | 1.84           | 230              | 100                       |
| GDE in 1 kg of dry matter, MJ    | 10.1       |                             |                |                  |
| Age, from 7 to 10 months         |            |                             |                |                  |
| Group I                          |            |                             |                |                  |
| Cereal-legume hay                | 0.53       | 0.36                        | 0.46           | 53               |
| Cereal-legume haylage            | 1.44       | 0.65                        | 0.79           | 79               |
| Hay + haylage (rough)            | 1.97       | 1.01                        | 1.25           | 76.7             |
| Compound feed                    | 0.45       | 0.54                        | 0.38           | 64               | 23.3                      |
| Total                            | 1.55       | 1.63                        | 196            | 100              |
| GDE in 1 kg of dry matter, MJ    | 9.5        |                             |                |                  |
| Group II                         |            |                             |                |                  |

The analysis of the composition and nutritional value of diets for rams at the age of from 7 to 10 months showed that the structure of the rations changed with time, with the share of compound feed decreasing and the roughage fodder increasing in the rations. The amount of concentrated feed decreased from 28.6 to 23.3% in Group I and from 40 to 30% in Group II. So, the part of roughage fodder—hay and haylage—increased. In Group I, the gross digestible energy was 1.55 EFU and crude protein was 196 g. In Group II, these indices were 1.85 EFU and 230 g, i.e. by 19.4 and 17.3% higher than in Group I. The concentration of digestible energy in 1 kg of dry matter was higher by 0.6 EFU or 6.3% in Group
II than in Group I. These changes in the nutritional value of the diets affected the rams’ productivity in Group II and, first of all, the dynamics of body weight and meat productivity.

The results of studying the dynamics of the rams’ body weight are shown in table 3.

Table 3. The dynamics of live weight and daily gains of Romanov sheep rams from 3 to 10 months of age.

| Group | Age, months | Overall gain, kg | Daily gain, g |
|-------|-------------|------------------|---------------|
|       | 3 to 7      | from 3 to 7      | from 7 to 10  |
| I     | 16.01±0.25  | 16.61            | 12.53         |
| II    | 16.07±0.27  | a 22.34          | a 16.59       |
|       | 7 to 10     | 45.15±0.53       | 138           |
| I     | 38.41±0.30  | 139              | 186           |
| II    | 55.0±0.48   | 184              | 186           |

* P≤0.001.

The data in table 3 show that an increase in the energy and protein nutrition of the 3-7 month old rams in Group II caused an increase in the daily gain by 48 g or 34.8%. In terms of the live weight, the difference between the groups made 5.79 kg or 17.75% and was significant as P≤0.001. At the age of 10 months, the difference in the live weight was highly significant, i.e. 9.85 kg or 21.82%. With respect to the daily gain at this age, the difference was 45 g or 32.37%.

The control slaughter of rams at the age of 7 months showed that in terms of the pre-slaughter weight, the difference between the groups was 5.74 kg or 19.2%. In terms of the hot carcass weight, the Group II rams significantly exceeded the Group I rams by 2.82 kg or 21.3%, (P<0.001). With respect to the slaughter weight, the difference was 3.97 kg or 29.0% as P<0.001 (td=11). The slaughter yield increased from 45.7% to 49.5% or by 3.8 absolute percent.

The carcass yield increased from 44.3% to 45.1% or by 0.8 absolute percent in Group II. The deboning carcasses of rams slaughtered at the age of 7 months showed that the weight of the longissimus muscle of rams in Group II was by 240 g greater than that of rams in Group I. The weight of flesh meat increased from 7.37 kg to 9.62 kg or by 2.25 kg and 30.5%. The difference in chilled carcass weight was 2.85 kg. The difference in all these indicators was significant as P<0.01. Their carcass fat weight in Group II was also higher by 230 g and internal fat by 1.14 kg or 15.0% and 3.8 times more at a high significance.

The morphological composition of the carcass gave an objective characteristic of the meat properties of lamb; its chemical composition indicated the taste of the meat. The study of the histological structure of the longissimus muscle made it possible to more objectively and comprehensively assess the quality of young lamb, find out the ratio between the tissues and the tenderness of the muscle tissue, and so on. The values of the histological sections of the longissimus muscle of the Romanov rams slaughtered at the age of 7 months are presented in table 4. The feeding conditions in a certain way affected the histology of the longissimus muscle of the experimental rams (table 4). So, in Group II, the diameter of muscle fibers increased by 4.3 microns or 15.7%; the diameter of the fat cells increased even more, i.e. by 6.2 microns or 10.4%; the number of muscle and fat cells per 1 cm² of the longissimus muscle increased and amounted to 5.6 and 28.6%, respectively.

Table 4. Histological structure of the longissimus muscle.

| Group | Diameter, μm | per 1 cm² | Width of connective tissue, μm | Area of eye of loin, cm² | Weight of the longissimus muscle, g |
|-------|--------------|-----------|--------------------------------|--------------------------|-----------------------------------|
| I     | 27.4±0.95    | 701±12.15 | 35.4±1.12                      | 25.4±1.43                | 0.59±0.03                         |
| II    | 31.7±1.0 a   | 743±10.12 | 30.7±1.14                      | 30.1±1.17                | 0.83±0.03                         |

a P≤0.05; b P≤0.01.
The parameters of the intermuscular connective layer are characterized by the loosening of the muscle bundles and significantly affect the taste of meat. The wider are the intermuscular connective layers, the looser is the muscle, so the worse is the taste and nutritional properties. The width of the connective tissue in Group II decreased slightly, by 5.2 microns or 14.7%.

The results of studying the rams and ewe lambs' wool productivity at different feeding conditions are presented in Table 5.

**Table 5.** Wool shorn from a lamb and from 7 month old rams of the Romanov breed (n=15) in the discount areas (4x4).

| Group | Wool shorn from lambs, kg | Clean wool yield, % | Wool shorn from 7 month old rams, in discount areas, g | Clean wool yield, % |
|-------|--------------------------|---------------------|--------------------------------------------------------|---------------------|
| Rams  |                          |                     |                                                        |                     |
| I     | 1.34±0.04 ±0.02          | 70.77±0.31          | 2.39±0.08                                              | 71.94±0.32          |
| II    | 1.61±0.03 ±0.02 a        | 71.51±0.23          | 3.05±0.06 a                                            | 72.45±0.21          |

*a P ≤ 0.001.

The data obtained allowed claiming that the rams in Groups I and II had the difference between original and clean shorn wool of 0.27 and 0.20 kg or 20.1 and 21.1% in favor of the rams in Group II with increased energy and protein in their diets. In terms of the clean equivalent weight, the difference between the groups was not large or significant. With respect to the clean wool shorn from the discount area, the difference between the groups was 0.49 g or 28.5%.

To study the effect of feeding conditions on the thickness of skin and its layers, we made histological preparations of skin of experimental rams (vertical incisions). The skin biopsy was performed on the right side of the 7 month old rams.

When reading the skin preparations, we got the following results (Table 6). The data obtained indicated, that the total skin was thicker in Group II (with intensive feeding) than in Group I by 523 microns or 22.6%, with the pilar layer being thicker by 231 microns or 15.1%. The thickness of the reticular layer that determines the strength of the sheepskin increased by 290.5 microns or 38.8% in Group II; its percentage of the total skin thickness increased from 32.4 to 36.7%.

**Table 6.** Thickness of sheepskin and its layers of 7 month old Romanov rams (μm), (n=7).

| Group | Total skin thickness | Pilar layer | % of total thickness | Reticular dermis | % of total thickness | Epidermis | % of total thickness | Skin weight, kg |
|-------|----------------------|-------------|----------------------|------------------|----------------------|-----------|----------------------|----------------|
| I     | 2311±76              | 1532±63     | 66.3                 | 748.7±22         | 32.39                | 30.3±1.2  | 1.31                 | 3.78±0.10      |
| II    | 2834±62 a            | 1763±51 b   | 62.2                 | 1039.3±19 a      | 36.68                | 31.7±0.9  | 1.12                 | 4.57±0.09 a    |

*a P≤0.001; b P≤0.02

The thickness values of the ram skin determined in the laboratory were consistent with the weighing indices of hot skins obtained after slaughter. The weight of a hot skin was 3.78 kg in Group I and 4.57 kg in Group II that was by 0.79 kg (20.9%) heavier. The difference was significant as P≤0.001.

An increase in the energy and protein nutrition in Group II had a positive effect on the digestibility of all nutrients in the diets. So, the digestibility of dry matter increased by 4.04 absolute percent, organic matter by 3.97%, digestibility of crude protein and fiber increased significantly by 6.97 and 5.2 absolute percent, respectively. The digestibility of fat also increased even without nitrogenous extractive substances. The high digestibility of crude fiber in Group II rams required special attention. Apparently, fiber in the roughage fodder was low in lignin, which contributed to the high digestibility of not only feed fiber, but also other nutrients.
The efficiency of the feed consumption was judged by the consumption of energy and nutrients of the rations per 1 kg of the body weight gain. The lower are these costs, the more efficiently is the animal feed used for the production of muscle tissue and wool, synthesis of milk, and other animal products. Based on nutritional value of diets of rams at the age of from 3 to 7 months and from 7 to 10 months and weight gains during these periods of the experiment, we calculated the costs of dry matter, metabolic energy, and crude protein for an increase of 1 kg of the body weight. The results are shown in table 7.

**Table 7.** Dry matter, metabolic energy, and protein spent on the increase in 1 kg of the rams’ body weight by periods of the experiment.

| Age, months | Group | Parameter                                      | Dry matter, kg | Metabolic energy, EFU | Crude protein, g |
|-------------|-------|------------------------------------------------|----------------|-----------------------|-----------------|
| 3-7         | I     | Spent over the period of 120 days               | 145.2          | 141.6                 | 17.64           |
|             | II    |                                                | 174            | 180.0                 | 22.08           |
|              |       | Increase obtained for the period, kg           | 16.61          |                       |                 |
|              | I     | Spent on 1 kg of growth                        | 8.76           | 8.53                  | 1063            |
|              | II    |                                                | 7.80           | 8.07                  | 990             |

The data in table 7 show that in Group II compared with Group I, the dry matter consumed per 1 kg of gain decreased by 1.73 kg or 14.8%, exchange energy by 1.22 EFU or 11.0%, and crude protein by 160 g or 11.4%.

4. **Conclusions**

According to the study results, we can conclude that an increase in the energy and protein nutrition in the diets of Romanov rams from 3 to 7 months of age contributed to an increase in the growth intensity of the animals. The live weight of the Group II rams at the age of 7 months was by 5.79 kg or 17.75% greater than that of the animals in Group I, so did the daily gain—it increased from 138 g to 186 g. In terms of the daily gain, the difference at this age was 45 g or 32.37%. The control slaughter found that the pre-slaughter weight of the Group II rams increased by 9.73 kg or 22.3% compared with Group I; the hot carcass weight by 5.08 kg or 25.5%; and the slaughter weight by 6.4 kg or 31.1 %. The difference was significant in all cases as P≤0.001. The slaughter yield increased from 47.3% to 50.7% or by 3.4 absolute percent. The histological studies of the *longissimus* muscle showed that the diameter of muscle fibers increased by 4.3 μm or 15.7% in Group II. The diameter of the fat cells increased even more—by 6.2 microns or 10.4%; and the number of muscle and fat cells increased per 1 cm² of the *longissimus* muscle and amounted to 5.6 and 28.6%, respectively. The width of the connective tissue decreased slightly by 5.2 microns or 14.7% in Group II.

The difference between the original and clean wool shorn from lamb in Groups I and II was 0.27 and 0.20 kg, or 20.1 and 21.1% in favor of rams in Group II with increased energy and protein contents in their diets. In terms of the yield of clean wool, the difference between the groups was not large or significant. According to the clean wool shorn from the discount area, the difference between the groups was 0.49 g or 28.5%. The histological study of the skin showed that the total skin thickness was higher by 523 μm or 22.6% in Group II (with intensive feeding), with the pilar layer being thicker by 231 microns or 15.1%. The thickness of the reticular layer that determines the strength of the sheepskin increased by 290.5 microns or 38.8% in Group II; its percentage of the total skin thickness increased from 32.4 to 36.7%.

The 3-7 month old Romanov rams with a live weight of 16-38 kg and 186 g of the daily body weight gain had requirements for 1.45 kg of dry matter, 1.50 EFU of exchange energy and 186 g of crude
protein per 1 head a day at a cost of 7.8 kg of DM, metabolic energy of 8.06 EFU, and 988 g of crude protein per 1 kg of increase, respectively.

Acknowledgments
The research study proposed was conducted under the grant of the Russian Science Foundation No. 19-76-10010, SSI NIIMMP “Scientific and practical justification for increasing the efficiency of intensification of livestock production in the arid conditions of the Russian Federation”.

References
[1] Smirnov L F 1953 Romanov sheep (Russia: Moscow) p 231
[2] Erokhin A I, Karasev E A and Erokhin S A 2005 Romanov breed of sheep: state, improvement, use of the gene pool (Russia: Moscow) p 329
[3] Kutrovsky V N, Nikolaychev V A and Puretsky V M 2010 Theory and practice of Romanov sheep breeding in the Non-Chernozem zone of the Russian Federation (Moscow: Russian State Agrarian University - Moscow Timiryazev Agricultural Academy) p 209
[4] Dvalishvili V G, Zhiryakov A M and Milchevsky V D 2016 Creation of a new meat and fur type of multi-fertile sheep Animal Science 5 3-5
[5] Dvalishvili V G 2015 Some reserves for increasing the mutton production Sheep, goats, woolen business 4 21-3
[6] Gorlov I F, Slozhenkina M I, Mosolov A A, Knyazhechenko O A and Miroshnikova E P 2019 Muscular tissue of steers and rams grown in conditions of arid pastures: analysis of microelement composition IOP Conf. Ser.: Earth and Environmental Science 012171
[7] Dvalishvili V G and Stepanenko I V 2009 Meat productivity of young animals of different origins Achievements of science and technology of the agro-industrial complex 1 43-6
[8] Dvalishvili V G and Aziz N 2012 Meat-fur coat type of Romanovskaya breed sheeps Zootechniya 5 30-1
[9] Dvalishvili V G, Fathala M M, Vinogradov I S, Dawod A 2015 Influence of crossbreeding Romanov ewes with crossbred argali x Romanov rams on male progeny performance and carcass traits J. Veterinary Science and Technology 6 275
[10] Fathala M M, Dvalishvili V G, Nikishov A A, and Sheikh Е I 2012 Productive Performance and Carcass Traits of Tsigai x Romanov Crossbred lambs in Type of Romanov Breed Alex. J. Sci 37(1)
[11] Dvalishvili V G 2019 Weight growth and meat productivity of purebred and ¼ blooded Romanov-Edilbay rams with different feed efficiency Sheep, goats, woolen business 2 34-6
[12] Dvalishvili V G 2017 Different levels of protein and productivity of Romanov sheep rams Izvestia of Gorskoy State Agrarian University 54 68-72
[13] Modyanov A V, Stepanova G N and Dvalishvili V G 1985 Carbohydrate composition and energy nutritional value of sheep rations Bulletin of Agricultural Sciences 4 121-6
[14] Dvalishvili V G, Kaplinskaya L I, Cusina A A 2009 The histostructure of the skin, shearing and the quality of sheep wool when feeding metasmart Sheep, goats, wool business 4 63-6
[15] Dvalishvili V G 2013 The structure of the diet for intensive growing and fattening of young sheep of the Romanov breed Farm animals 3-4 96-101