The influence of hereditary factors on the qualitative and quantitative indicators of milk

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Abstract. In the light of the requirements for the implementation of the priority national project “The Development of the Agro-Industrial Complex”, the accelerated development of the dairy cattle breeding industry in the coming years is one of the promising strategic directions of domestic production. For a long time, breeders were mainly engaged in increasing the milk yield of cows and increasing the mass fraction of fat in milk. As for the mass fraction of protein in milk, due attention was not paid to it, since there was no material interest in increasing this indicator, considering that milk during its sale was estimated by the total mass and the content of only the mass fraction of fat in it. This led to the fact that with a significant increase in milk yield and milk fat of cows, the fat-free solids content in milk decreased. However, since the amount of milk sugar and minerals in milk is practically unchanged, this decrease was due to the content of the mass fraction of protein in milk.

1. Introduction
According to most researchers, it is not only advisable, but also necessary to take into account the content of the mass fraction of protein in milk and conduct livestock breeding on this basis. This direction in breeding is especially important for new, recently developed breeds, which include the red-motley breed of dairy cattle [2,3,6,7].

The purpose of the research is to study the influence of hereditary factors on the protein content of milk of the red-motley breed cows in the conditions of the Krasnoyarsk Territory.

The research objectives are:

• to determine the dependence of the protein content of milk of the red-motley breed cows on genetic factors — belonging to lines, individual characteristics of the father and mother;
• to study the breeding and genetic parameters of milk production of cows;
• to determine the economic efficiency of milk production of the red-motley breed, depending on the line.

2. Materials and methods
The studies were conducted on the basis of the breeding factory of JSC "Red Mayak" of the Krasnoyarsk Territory. The livestock of the red-motley breed of dairy cattle in the breeding plant is represented mainly by the lines R. Sowering 0198998, M. Chiftein 95679, and S. T. Rokit 252803. Therefore, three groups of first-calf cows of the red-motley breed of 50 animals of different lines were formed. The first
The repeatability coefficient of milk yield in the groups was 0.68 - 0.72.

3. Results and discussions

It was established (table 1) that cows of the M.Chiftein line exceeded animals of other genealogical groups by milk yield per 100 lactation days by 111-257 kg (10.3–12.5%), by protein content of milk – by 7.2–9.0 kg (9.7–12.2%) and fat content of milk – by 9.2–11.8 kg (9.4–12.1%). Over 305 days – by 250-426 kg (3.8–6.6%), 8.4-9.2 kg (4.3-4.8%), 9.4-12 kg (3.7–4.7%) respectively. The difference is reliable (P ≥ 0.999) over both 100 and 305 days of lactation.

The data obtained showed that, regardless of belonging to lines, the variability of milk yield was quite high in all groups of animals and ranged from 14.2 to 16.3% per 100 days of lactation and from 9.9 to 13.3% per 305 days of lactation. The coefficients of variability in the mass fraction of protein and fat in milk were significantly lower and amounted to 2.7–5.4% and 3.3–6.1% for 100 days of lactation, and 1.3–1.7 for 305 days and 1.5-3.0%, respectively. The variability of protein and fat content of milk occupied an intermediate position: from 4.4-6.2% and 3.9-5.1% for 100 days of lactation, 5.4-9.4% and 5.5-8.1 % for 305 days, respectively.

Table 1. Indicators of milk productivity of cows and their variability.

| Line               | Milk yield, kg | Mass fraction of protein, % | Amount of milk protein, kg | Mass fraction of fat, % | Amount of milk fat, kg |
|--------------------|----------------|-----------------------------|---------------------------|------------------------|------------------------|
|                    | M±m            | M±m                         | M±m                       | M±m                    | M±m                    |
|                    | Cv, %          | M±m                         | M±m                       | M±m                    | M±m                    |
| M. Chiftein        | 2489±54.7      | 15.6                        | 2.97±0.02                 | 3.7                    | 73.9±0.6               | 6.2                    | 3.93±0.02                | 4.5                    | 97.8±1.0                | 5.1                    |
| R. Sowering        | 2178±43.8      | 14.2                        | 2.98±0.01                 | 2.7                    | 64.9±0.6               | 4.6                    | 3.95±0.03                | 6.1                    | 86.0±0.6                | 3.9                    |
| S.T. Rokit         | 2232±51.5      | 16.3                        | 2.99±0.02                 | 5.4                    | 66.7±1.0               | 4.4                    | 3.97±0.02                | 3.3                    | 88.6±1.0                | 5.0                    |
| Over 100 days of lactation |  |                      |                  |                      |                       |                      |                      |                      |                      |                      |
| M. Chiftein        | 6446±90.1      | 9.9                         | 3.00±0.01                | 1.3                    | 193.4±1.0             | 8.3                    | 3.95±0.01                | 3.0                    | 254.6±1.3               | 8.1                    |
| R. Sowering        | 6196±117.3     | 13.3                        | 2.99±0.01                | 1.7                    | 185.0±1.0             | 9.4                    | 3.96±0.01                | 1.5                    | 245.2±1.0               | 7.6                    |
| S.T. Rokit         | 6020±101.6     | 11.9                        | 3.06±0.01                | 1.3                    | 184.2±1.1             | 5.4                    | 4.04±0.02                | 1.5                    | 242.6±1.4               | 5.5                    |
| Over 305 days of lactation |  |                      |                  |                      |                       |                      |                      |                      |                      |                      |

A study of the repeatability of milk productivity characteristics over 100 and 305 days of lactation revealed a certain pattern (table 2). Regardless of belonging to certain lines of the cows, the mass fraction of protein in milk was characterized by the highest repeatability coefficient - 0.94-0.97, then was the mass fraction of fat - 0.91-0.95, the protein content of milk - 0.73-0.81 and the fat content of milk - 0.71-0.76. The repeatability coefficient of milk yield in the groups was 0.68-0.72.

Table 2. The repeatability of milk productivity characteristics.

| Characteristic                        | Line     |
|---------------------------------------|----------|
|                                       | M. Chiftein | R. Sowering | S.T. Rokit |
| Milk yield, kg                        | 0.72     | 0.68        | 0.69       |
| Mass fraction of protein in milk, %   | 0.93     | 0.89        | 0.97       |
| Quantity of milk protein, kg          | 0.81     | 0.73        | 0.76       |
| Mass fraction of fat in milk, %       | 0.94     | 0.95        | 0.90       |
| Quantity of milk fat, kg              | 0.81     | 0.73        | 0.77       |
Since the repeatability coefficients of the mass fraction of protein and fat in milk are very high, it is possible to use these characteristics when selecting at an early age (after 100 days of lactation) [1,4,5].

Between the indicators of milk productivity, there is a different correlation in direction and magnitude (table 3). In all the cattle of the compared groups, the mass fraction of protein positively correlates with the fat content of milk. A close and positive correlation is established between the quantity of milk fat and milk yield, milk protein and milk yield. Between the milk yield and the mass fraction of fat and protein in milk, there is mainly a negative correlation, with a few exceptions—a weak positive one.

Table 3. The correlation between the indicators of milk productivity in first-calf cows of different lines.

| Paired characteristics | Line          |          |          |          |
|------------------------|---------------|----------|----------|----------|
|                        | M. Chiftein   | R. Sowering | S.T. Rokit |
|                        | Over 100 days of lactation |          |          |          |
| Milk yield x MFP       | -0.09         | -0.08    | -0.07    |
| Milk yield x MFF       | +0.002        | +0.09    | -0.16    |
| Milk yield x Milk protein | +0.80         | +0.77    | +0.79    |
| Milk yield x Milk fat  | +0.86         | +0.81    | +0.77    |
| MFP x MFF              | +0.23         | +0.29    | +0.36    |
|                        | Over 305 days of lactation |          |          |          |
| Milk yield x MFP       | -0.07         | -0.15    | -0.17    |
| Milk yield x MFF       | -0.03         | -0.19    | -0.25    |
| Milk yield x Milk protein | +0.98         | +0.95    | +0.94    |
| Milk yield x Milk fat  | +0.97         | +0.98    | +0.98    |
| MFP x MFF              | +0.87         | +0.42    | +0.74    |

The effect of the milk yield level on the protein and fat content in the milk of cows of different lines was studied (table 4). It was found that in the cattle of the M.Chiftein line, with an increase in the level of milk yield, a decrease in the mass fraction of protein from 3.12 to 2.78% and the mass fraction of fat from 4.12 to 3.68% are observed. The cows with milk yield up to 6000 kg in terms of mass fraction of protein in milk exceeded the cows with a milk yield of 6001-6500 or more, respectively, by 0.13 and 0.34%, in fat content by 0.13 and 0.42%.

In the cattle of the R. Sowering line, the best quality milk was obtained from the cows with a milk yield of 6001 to 6500 kg. A further increase in the level of milk yield leads to a decrease in the mass fraction of protein to 2.88%, fat to 3.75%. However, the amount of milk protein and milk fat increased from 162 to 223 kg and from 214 to 300 kg, respectively. A greater increase in the amount of milk protein and milk fat occurred with an increase in milk yield among the daughters of the M. Chiftein line (by 26.0 and 27.0%), at P> 0.95.

The daughters of the stud bulls of the M. Chiftein line show a regular decrease in the variability of the amount of milk protein (from 5.4 to 2.1%) with an increase in the level of milk yield. The same tendency to decrease in the variability of the amount of milk protein was noted in the 2nd group (from 8.0 to 3.0%). In the 3rd group, the lowest coefficient of variation in the amount of milk protein (2.0%) was found in cows with a milk yield of 6501 to 7000 kg.

Table 4. Protein and fat content in milk of first-calf cows, depending on the amount of milk yield and belonging to the line.

| Cattle group by milk yield, kg | Mass fraction of protein, % | Quantity of milk protein, kg | Mass fraction of fat, % | Quantity of milk fat, kg |
|-------------------------------|-----------------------------|-----------------------------|------------------------|-------------------------|
|                               | M±m | Cv, % | M±m | Cv, % | M±m | Cv, % | M±m | Cv, % |
| M. Chiftein                   |     |       |     |       |     |       |     |       |
Studies show that the correlation between the level of milk yield and the mass fraction of fat and protein in milk in cattle groups does not have a clear pattern. Therefore, even in herds with a milk yield of 6501-7000 kg, one can select simultaneously according to three characteristics – milk yield, mass fraction of protein and fat in milk [4,8].

As can be seen from the data in table 5, a significant positive and high correlation was established between the amount of milk protein, milk fat and milk yield in first-calf cows of all the lines, and the selection of cows by the amount of milk yield will lead to an increase in the amount of milk protein and fat.

The correlation coefficients between the mass fraction of protein and fat in milk depending on the level of milk yield in all the groups are positive (0.10 - 0.87).

Thus, it was found that with an increase in milk yield, a decrease in the positive correlation between the mass fraction of fat and protein in cow’s milk was observed. The correlation coefficient turned negative in the first group with a yield of 6001-6500 kg, in the 2nd and 3rd – from 6501-7000 kg. This is due to a decrease in the concentration of fat and protein in milk with an increase in milk yield.

**Table 5.** The effect of the milk yield of cows on the correlation between the indicators of milk productivity.

| Cattle group by milk yield, kg | n  | Correlation coefficient | Between |
|-------------------------------|----|-------------------------|---------|
|                               |    | Of milk yield with      |         |
|                               |    | MFP, %                  | MFF, %  |
|                               |    | Milk protein, kg        | Milk fat, kg | MFP-MFF |

| M. Chiftei | Up to 6000 | 15 | +0.03 | -0.10 | +0.97 | +0.98 | +0.10 |
|------------|------------|----|-------|-------|-------|-------|-------|
| 6001-6500  | 17         | -0.21 | -0.17 | +0.89 | +0.71 | +0.36 |
| 6501-7000  | 11         | -0.02 | -0.04 | +0.68 | +0.73 | +0.12 |
| More than 7001 | 7      | -0.53 | -0.90 | +0.76 | +0.98 | +0.16 |

| R. Sowering | Up to 6000 | 19 | -0.02 | +0.01 | +0.82 | +0.84 | +0.95 |
|------------|------------|----|-------|-------|-------|-------|-------|
| 6001-6500  | 16         | +0.19 | +0.10 | +0.66 | +0.83 | +0.23 |
| 6501-7000  | 7          | -0.06 | -0.68 | +0.24 | +0.61 | +0.46 |
| More than 7001 | 8      | -0.81 | -0.25 | +0.99 | +0.95 | +0.34 |

| S.T. Rokit | Up to 6000 | 19 | -0.02 | +0.01 | +0.82 | +0.84 | +0.95 |
|------------|------------|----|-------|-------|-------|-------|-------|
| 6001-6500  | 16         | +0.19 | +0.10 | +0.66 | +0.83 | +0.23 |
| 6501-7000  | 7          | -0.06 | -0.68 | +0.24 | +0.61 | +0.46 |
| More than 7001 | 8      | -0.81 | -0.25 | +0.99 | +0.95 | +0.34 |
Up to 6000  32  +0.10  -0.32  +0.72  +0.85  +0.53
6001-6500  9   -0.22  -0.04  +0.63  +0.70  +0.76
6501-7000  6   -0.64  -0.49  +0.77  +0.71  +0.64
More than 7001  3  -0.32  -0.50  +0.99  +0.99  +0.87

The identification of stud bulls that increase the mass fraction of protein in daughters’ milk and their widespread use largely determines the intensity of domestic cattle improvement in protein content of milk.

In the herd of the Krasny Mayak breeding factory, there are stud bulls with a good combination of the main components of milk in the offspring; for example, the daughters of the Viking bull 1399 have 3.05% protein, and 4.06% fat. The daughters of the Nightingale bull 5427 are also characterized by a high milk yield. Therefore, the milk yield of the daughters of the Nightingale bull 5427 over 305 days of lactation is 6423 kg with a mass fraction of fat of 4.10% and a mass fraction of protein of 3.12%.

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The highest quantity of milk fat and protein is the result of the highest milk yield, as well as the high mass fraction of fat and protein in milk.

The value of the heritability estimate serves as the main indicator of the selection effectiveness according to the selection trait and allows us to judge the possible degree of improvement by selection. The data obtained by doubling the correlation coefficient between mothers and daughters showed that the heritability of the milk yield is 0.35-0.46. Highly heritable characteristics are the mass fraction of fat and protein in milk. The heritability estimate was 0.68-0.73 and 0.65-0.75, respectively.

The calculation of economic efficiency showed the feasibility of using the first-calf cows of the M. Chiftein line, since more profit was obtained from these cattle compared to the peers of the R. Sowering and S. T Rokit lines, with a profitability level of 73.37%.

As a result of recalculation of the milk yield to the basic mass fraction of fat (3.4%) and protein in milk (3.2%), M. Chiftein cows had the highest milk yield over 305 days of lactation – 7488 kg. It is 272 kg or 3.6% more than the first-calf cows of the R. Sowering line, and 335 kg (4.5%) more than the similar indicator of the first-calf cows of the S. T. Rokit line.

Table 6. Economic indicators of milk production of cows of different lines.

| Characteristics                        | M. Chiftein | R. Sowering 198998 | S. T. Rokit 252803 |
|----------------------------------------|-------------|--------------------|--------------------|
| Milk yield over 305 days of lactation, kg | 6446        | 6196               | 6020               |
| Mass fraction of fat in milk, %        | 3.95        | 3.96               | 4.04               |
| Mass fraction of protein in milk, %    | 3.00        | 2.99               | 3.06               |
| Milk yield in terms of the base proportion of fat (3.4%) in milk, kg | 7488        | 7216               | 7153               |
| Costs of milk production, rub.         | 71285.8     | 69864.1            | 69799.0            |
| Production cost of 1 kg of milk, rub.  | 9.52        | 11.3               | 11.6               |
| Revenue from the milk sale, rub.       | 123589.44   | 110476.96          | 110370.79          |
| Profit from the milk sale, rub.        | 52303.64    | 40612.96           | 40571.79           |
| Profitability of milk production, %    | 73.37       | 58.13              | 58.12              |
4. Conclusion
Between indicators of milk productivity, a different correlation was established in direction and magnitude. Thus, the mass fraction of protein positively correlates with the mass fraction of fat in milk \( (r = 0.42 – 0.84) \); a close and positive correlation was found between the amount of milk fat and milk yield \( (r = 0.97 – 0.98) \), milk protein and milk yield \( (r = 0.94 – 0.98) \); and basically a negative correlation was found between milk yield and mass fraction of fat \( (r = 0.03 – 0.25) \) and mass fraction of protein in milk \( (r = 0.07 – 0.17) \). High repeatability ratios of the mass fraction of protein \( (0.94 – 0.97) \) and the mass fraction of fat \( (0.91 – 0.95) \) allow selection according to these criteria at an early age (after 100 days of the first lactation). The belonging of cows to specific lines had a positive impact on the economic efficiency of milk production. The milk sale of the first-calf cows of the Montvik Chiftein line brought more profit by 20.8% compared to the peers of the Reflection Sowering and Sealing Trajun Rokit lines.

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