Milk productivity and physical and chemical properties of milk of red-motley cow breed

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Abstract. Increasing the milk yield and improving the qualitative composition of milk are crucial tasks in Russia and foreign countries. In Krasnoyarsk krai, red-motley cows occupy the largest share of all breeds (69.7%). Studies were conducted in the Arefyevskoye JSC of Krasnoyarsk krai on red-and-white breed cows. Physical and chemical properties of milk were determined in the laboratory of selection control of milk quality. Studies have shown that in red-motley breed cows, the milk yield, fat and dry matter increases with aging, and the number of somatic cells decreases. A high reliable relationship between the signs of qualitative composition of milk (fat - urea, lactose - urea, dry matter - urea, protein - dry matter, fat - dry matter and lactose - dry matter) in all lactation cows was established. For 305 days of lactation, the correlation between the signs of milk yield - fat and milk yield - protein was negative, the correlation between fat and protein content was positive.

1. Introduction
Currently, one of the main tasks in the dairy cattle industry of the Russian Federation and other countries is to increase animal productivity and milk quality [1-7]. Breeding is aimed at selecting animals with a high milk yield and a high content of fat and protein [8-11]. A certain interest of Russian and foreign researchers is caused by correlations between the signs of milk production: W M Stoop et al. analyzed the relationship between urea nitrogen and SCS (assessment of the level of somatic cells), fat, protein, and lactose, fat yield, protein, lactose, milk yield and the concentration of net energy of milk [12]. A Costa et al. established the relationship between lactose content and SCS, the freezing point, the yield of lactose and milk yield.

The article aims to determine the milk yield and qualitative composition of milk depending on the age of cows (the number of lactations).

2. Materials and methods
Studies were conducted in the Arefyevskoye JSC of Krasnoyarsk Territory on cows of a red-motley breed at the age of 1st, 2nd and 3rd lactations. The physicochemical properties of milk were determined in the laboratory of milk quality control using a Bentley DairySpec FT milk analyzer (USA). All data were processed using methods of variation statistics. The difference between the groups was determined by the Student's t-test. The difference was considered significant at P <0.05 and below. The relationship between the signs was determined by the correlation analysis.
### Table 1. Milk productivity of cows for 305 days of lactation

| Indicator         | M±m         | Cv  | Min  | Max  |
|-------------------|-------------|-----|------|------|
| **Lactation 1 (n=192)** |             |     |      |      |
| Milk yield, kg    | 5272.6±53.09| 13.95| 3413 | 8086 |
| MFF, %            | 3.96±0.01   | 1.96 | 3.78 | 4.25 |
| MPF, %            | 3.13±0.01   | 0.56 | 3.09 | 3.19 |
| **Lactation 2 (n=177)** |             |     |      |      |
| Milk yield, kg    | 5779.0±70.72| 16.28| 3928 | 8548 |
| MFF, %            | 3.93±0.01   | 2.22 | 3.73 | 4.18 |
| MPF, %            | 3.12±0.01   | 0.52 | 3.08 | 3.22 |

### Table 2. Physical and chemical properties of milk

| Indicator         | M ± m         | Cv  | Min  | Max  |
|-------------------|---------------|-----|------|------|
| **lactation 1 (n = 192)** |             |     |      |      |
| MFF, %            | 3.42 ± 0.055  | 22.32| 1.25 | 5.82 |
| MPF, %            | 3.31 ± 0.018  | 7.49 | 2.65 | 3.96 |
| MF of lactose, %  | 5.09 ± 0.023  | 6.37 | 1.9  | 5.68 |
| Dry matter, kg    | 12.66 ± 0.069 | 7.50 | 10.35| 15   |
| NMS, %            | 17.71 ± 5.976 | 467.52| 0.04 | 837  |
| Urea, mg / 100 ml | 16.08 ± 0.420 | 35.86| 4.58 | 30.02|
| Somatic cells 10³/1 ml | 351.14 ± 34.830 | 137.43| 32   | 3636 |
| **lactation 2 (n = 177)** |             |     |      |      |
| MFF, %            | 3.47 ± 0.062  | 23.67| 1.74 | 5.98 |
| MPF, %            | 3.30 ± 0.017  | 6.85 | 2.48 | 3.95 |
| MF of lactose, %  | 5.06 ± 0.015  | 3.89 | 4.36 | 5.6  |
| Dry matter, kg    | 12.57 ± 0.098 | 10.34| 1.6  | 15.25|
| NMS, %            | 9.17 ± 0.033  | 4.74 | 8.18 | 10.55|
| Urea, mg / 100 ml | 15.78 ± 0.500 | 42.50| 2.96 | 30.84|
| Somatic cells 10³/1 ml | 372.34 ± 31.430 | 112.31| 31   | 2650 |
| **lactation 3 (n = 201)** |             |     |      |      |
| MFF, %            | 3.55 ± 0.057  | 22.81| 1.63 | 5.88 |
| MPF, %            | 3.32 ± 0.013  | 5.40 | 2.72 | 3.97 |
| MF of lactose, %  | 5.10 ± 0.014  | 3.86 | 4.37 | 5.55 |
| Dry matter, kg    | 12.77 ± 0.064 | 7.09 | 10.09| 15   |
| NMS, %            | 9.23 ± 0.027  | 4.16 | 8.33 | 10.3 |
| Urea, mg / 100 ml | 16.47 ± 0.440 | 37.77| 3.1  | 30.04|
| Somatic cells 10³/1 ml | 313.72 ± 21.000 | 94.90| 33   | 2768 |
| **Lactation 3 (n=201)** |             |     |      |      |
| Milk yield, kg    | 6145.4±68.25 | 15.74| 3708 | 8525 |
| MFF, %            | 3.89±0.01    | 1.84 | 3.73 | 4.12 |
| MPF, %            | 3.12±0.01    | 0.48 | 3.08 | 3.18 |
3. Results

3.1. Milk productivity and qualitative composition of milk

It was found that with aging, the milk yield increases by 9.6 (the 2nd lactation) and 6.3% (the 3rd lactation). However, fat content decreases by 0.03 and 0.04%. Variability of the milk yield, the mass fraction of fat and protein increase until the second lactation; by the third lactation, the variability decreases. The highest milk yield was observed in cows of the 3rd lactation - 6145.4 k, which was more than in cows of the 1st and 2nd lactations by 872.8 and 366.5 kg, respectively (p <0.001); cows of the second lactation had the milk yield larger than the cows of the first lactation by 506.3 kg (p <0.001). The fat content was higher by 0.07 and 0.04 % (the 2nd and 3rd lactations). According to the protein content, the difference between cows of different lactations was unreliable.

When physicochemical properties of milk (Table 2), no significant differences between cows of different ages were revealed. There was a difference by the NMS between cows of all ages (td = 1.41-1.43; p> 0.05) and the number of somatic cells between cows of the 3rd and 2nd lactations (SCC) (td = 1.55; p> 0.05).

3.2. The relationship between the qualitative composition of milk

As a result of calculation of correlation coefficients between all signs of the milk yield and the qualitative composition of milk, reliable interrelations were found for the following pairs of signs - Table 3.

| Pairs | Lactation (r ± m) |
|-------|-------------------|
|       | 1                 | 2                 | 3                 |
| fat - protein (for 305 LFL) | 0.23 ± 0.068 *** | 0.45 ± 0.060 *** | 0.33 ± 0.063 *** |
| milk yield - fat (for 305 LFL) | -0.47 ± 0.057 *** | -0.52 ± 0.055 *** | -0.63 ± 0.043 *** |
| milk yield - protein (for 305 LFL) | -0.33 ± 0.065 ** | -0.2 ± 0.071 ** | -0.32 ± 0.064 ** |
| protein - lactose | 0.04 ± 0.072 | 0.11 ± 0.074 | 0.15 ± 0.069 *
| protein - urea | 0.10 ± 0.072 | 0.33 ± 0.067 *** | 0.24 ± 0.067 *** |
| fat - protein | 0.26 ± 0.068 *** | 0.16 ± 0.074 * | 0.05 ± 0.071 |
| fat - urea | 0.31 ± 0.065 *** | 0.58 ± 0.050 *** | 0.55 ± 0.049 *** |
| lactose - urea | 0.42 ± 0.060 *** | 0.61 ± 0.047 *** | 0.50 ± 0.053 *** |
| NMS - Urea | -0.042 ± 0.072 | 0.61 ± 0.047 *** | 0.55 ± 0.049 *** |
| dry matter / urea | 0.48 ± 0.056 *** | 0.49 ± 0.058 *** | 0.71 ± 0.035 *** |
| protein - NMS | -0.06 ± 0.072 | 0.62 ± 0.046 *** | 0.53 ± 0.051 *** |
| lactose - NMS | -0.04 ± 0.072 | 0.66 ± 0.042 *** | 0.71 ± 0.035 *** |
| dry matter - NMS | 0.03 ± 0.072 | 0.49 ± 0.058 *** | 0.51 ± 0.052 *** |
| protein - dry matter | 0.49 ± 0.055 *** | 0.33 ± 0.067 *** | 0.28 ± 0.065 *** |
| fat - dry matter | 0.88 ± 0.017 *** | 0.71 ± 0.038 *** | 0.90 ± 0.013 *** |
| lactose - dry matter | 0.23 ± 0.068 *** | 0.25 ± 0.071 *** | 0.22 ± 0.067 ** |

Cows of all ages have a strong positive relationship (r = 0.71 ... 0.90; p <0.001) between the pair of signs "fat-dry matter". In first lactation cows, weak positive relationships (r = 0.26 ... 0.48; p <0.001) were found between the signs “fat-protein”, “fat-urea”, “lactose-urea”, “dry matter – urea”.

In second lactation cows, positive correlations (r = 0.16 ... 0.33; p <0.05; 0.001) were found between the signs “fat-protein”, “protein-dry matter”, “urea – protein”, “lactose-dry matter” and medium
correlations were found \((r = 0.49 \ldots 0.66; p < 0.001)\) between the signs “dry matter-urea”, “dry matter-NMS”, “lactose-urea”, “NMS-urea”, “protein-NMS”, “lactose-NMS”.

In third lactation cows and older, strong positive correlations between the signs “dry matter-urea” and “lactose-NMS” \((r = 0.71; p < 0.001)\) and medium positive correlations between the pairs “fat-urea” were revealed. \(\text{“Lactose-urea”, “NMS-urea”, dry matter-NMS ”}(r = 0.50 \ldots 0.55; p < 0.001)\).

The positive correlations between physicochemical properties of milk should be taken into account when breeding cattle for improving the quality of milk of the red-and-white breed.

4. Conclusion

It was revealed that cows of the red-motley breed increase the milk yield with aging, but fat content decreases. Signs of the qualitative composition of milk (fat, lactose, dry matter) correlate with the amount of urea \((r = 0.31–0.71; p < 0.001)\); protein, fat and lactose correlate with dry matter \((r = 0.31 - 0.71; p < 0.01-0.001)\). The correlation between the signs of milk yield - fat and milk yield - protein for 305 days of lactation was negative \((r = -0.24-0.33; p < 0.01-0.001)\), between fat and protein in milk for 305 days of lactation - high positive. For 305 days of lactation, the correlation between the signs of milk yield - fat and milk yield - protein was positive, the correlation between fat and protein content was positive.

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