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RESEARCH ON EFFECT OF MILKINGS FREQUENCY ON COWS' MILK PRODUCTION

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Abstract

In the present socio-economic context and environmental sustainability trend it is a high accent on milk production related with increased milk yield per cow. This study aims to explore the influence of milking technology for Holstein dairy cows on "milk" productivity and quality, at the farm level. Over three consecutive years, the dynamics of milk quantity and its quality parameters (% fat, % protein, somatic cells count, % dry matter) were followed. The values of these parameters changed as a result of the increase of milkings frequency per day, from two in the first year of study, to three milkings per day in the following years. The results were statistically analyzed, from the point of view of significance, using the Fisher and Student tests. The comparative analysis of the 3 years of production shows that milk production had a positive evolution, both in terms of quantity and quality.

Key words: *dairy cow, Holstein, milking technology, qualitative milk parameters.*

INTRODUCTION

Animals belonging to the taurine species hold the first place among the species bred in Romania, with particular importance due to their growth and exploitation technology and productions performances and the social and economic impact, in the context of Romania's integration into the European Union.

Dairy cows use in the most profitable way the consumed feed, which gives an advantage for their growth. It is 5-10 times more profitable to produce milk than to produce meat.

It is essential that the production capacity of the animals, the financial aspect and the elements of organizational management should be taken into account in the breeding technology of dairy cows at the current level (Vidu, 2006).

These aspects must be transferred into breeding techniques applied in farms in order to achieve large milk productions at a low cost. Everything depends on the good understanding of this economic sector and the mastery of the knowledge intended in breeding animals for milk (Maciuc, 2006; Maciuc et al., 2015; Huțu et al., 2020).

The importance of knowing the level of milk production is due to the fact that it is the main indicator for assessing cows from dairy breeds and those with mixed production abilities.

Setting out the productive capacity of the animals allows their ranking in order to create the selection groups, by identifying and nominating cow candidates for the status of bull mothers (Alexoiu & Roșu, 1988; Dinescu & Ștefănescu, 1997; Vintilă & Dronca, 2000; Velea & Mărginean, 2004).

Holstein cows have very good skills for both milk production and meat production.

The Holstein-Friesian breed has a good precocity, the age of morphological maturity being around 4 years old. The young females are admitted to reproduction at the age of 13-14 months, once the optimal weight for insemination is reached (380-400 kg live weight). The maximum milk production is recorded at the fourth lactation, and the average period of exploitation is approximately 3-4 lactations, with the production level being high throughout the duration of exploitation. Animals have docile behaviour.

The specific feed consumption is 0.9 - 1 UN/kg of milk, which makes the economy of the breed highly appreciated, and the milk index (somato-productive index) to be over 1/8.

Improper growing and exploitation conditions and lacks in the feeding and breeding of Holstein cows lead to a decrease of the productive performance, increasing the specific

consumption of food and the risk of disease manifestation (Diaconescu & Nicolae, 2012).
In the present socio-economic context and environmental sustainability trend it is a high accent on milk production related with increased milk yield per cow.
That is why it is important to measure milk productions and carry out qualitative analyzes of these productions, so that the improvement of these parameters can be achieved,
This requirement can be obtained by reducing the number of animals in the farms, by improving the breeding and exploitation conditions of animals and by applying a suitable milking technology, in order to maintain the health of the animals and the udder.

MATERIALS AND METHODS

Over three consecutive years (2018-2020), the dynamics of milk quantity and its quality parameters (% fat, % protein, somatic cells count, % dry matter) were followed, depending on the milking technology applied, changing from two milkings per day in 2018, to three milkings per day in the following years (2019, 2020).
The biological material studied was represented by lactating cows, whose milk production was subject to the Official Performance Control. The size of the statistically analysed samples was given by the number of controls performed annually (1283 controls in 2018, 2011 in 2019 and 1696 in 2020). The collected milk samples were analysed, from a qualitative point of view, with the help of the Milkoscan analyser. The results of the quantitative and qualitative parameters of the farm's milk production, obtained during the research period, were statistically analysed. The programs used were Microsoft Excell (Office 2010) and SPSS Statistics 20.0 for Windows.
In order to obtain valid results from a statistical point of view and to be able to say accurately whether or not there are significant differences regarding the amount of milk and qualitative parameters during the analysed period, the Student and Fisher statistical tests were used.

The Student test was calculated according to the following formula (Sandu, 1995):

$$\hat{t} = \frac{\bar{X}_1 \cdot \bar{X}_2}{\sqrt{\frac{(\sum X_1^2 + \sum X_1^2) \cdot (n_1 + n_2)}{(n_1 + n_2 - 2) \cdot (n_1 \cdot n_2)}}}$$

Also, for the Fisher test, the analysis of variance (ANOVA) was carried out with two sources of variation, in order to establish whether or not there were significant differences in the performances achieved between the groups of animals (Table 1) (Grosu, 2022).

Table 1. ANOVA (Analysis of Variance)

Source of variation (SV)	Between groups (I)	Within groups (i)	Total
Degrees of freedom (DF)	$DF_I = p - 1$	$DF_i = N - p$	$DF_T = N - 1$
Sum of squares (SS)	$SS_I = \sum C - CT$	$SS_i = \sum\sum X^2 - \sum C$	$SS_T = \sum\sum X^2 - CT$
Mean of squares (MS)	$MS_I = SS_I/DF_I$	$MS_i = SS_i/DF_i$	
Fisher	$\hat{F} = MS_I/MS_i$		

where:
p - number of groups;
N – total number of animals;
DF – degrees of freedom;
SS – sum of squares;
MS – mean of squares;
∑C – sum of corrections;
TC – total correction;
∑∑X2 – the sum of the squares of the values.

RESULTS AND DISCUSSIONS

1. Dynamics of milk production and quality parameters in the period 2018-2020

The data obtained through the Official Performance Control, for some of the milk quality parameters (fat percentage, protein percentage, number of somatic cells and dry matter), were subjected to primary analysis. The data taken and the units of measurement are according to the milk analyzer, Milkoscan (Table 2 and Figures 1-5).

Table 2. Descriptive statistics for the qualitative and quantitative parameters of milk production in 2018-2020 period

Specification	2018	2019	2020
Number of samples	1283	2011	1696
Milk (l/day/head)	24.65±0.16	26.98±0.157	29.10±0.13
Fat (%)	3.95±0.02	4.01±0. 018	4.32±0.01
Protein (%)	3.30±0.01	3.48±0. 010	3.41±0.01
Somatic Cells Count (x 1000/ml)	57.99±1.21	61.21±1.003	68.32±1.24
Dry matter % (m/m)	12.81±0.03	13.10±0.024	13.23±0.02

Figure 1 shows the ascending evolution of the amount of milk from one year to another. The amount of milk is higher in 2019 (26.98 l/day/head) compared to 2018 (24.65 l/day/head). In 2020 the average amount of milk/day/head of cow (29.10 l/day/head) is higher both compared to 2018 and compared to 2019. This is due to the change from 2 milkings/day in 2018 to 3 milkings/day in 2019, respectively 2020.

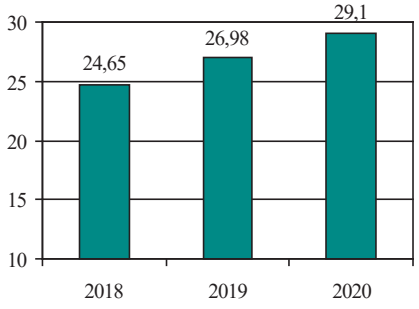

Figure 1. The dynamics of milk quantity in 2018-2020 period (l/day/head)

In the farm, the animals were selected with the aim of obtaining a new generation with a higher productive potential, and the feeding of the animals was constantly evolving and updating, which also led to an increase in milk production

It is very important to mention that the percentage of fat has also increased. The evolution of the fat percentage registers a continuous progress, thus in 2020 is observed the highest increase, due to the good quality of the volume feed, which indicates that the milk is not only in a high quantity, but also with a better quality (Figure 2).

The evolution of the protein percentage is different, the highest value being registered in 2019, then a decrease occurs in 2020 (Figure 3). This can be attributed to the fact that the two parameters, milk fat and protein, are inversely proportional, so that with an increase in the percentage of fat, there is a decrease in that of protein.

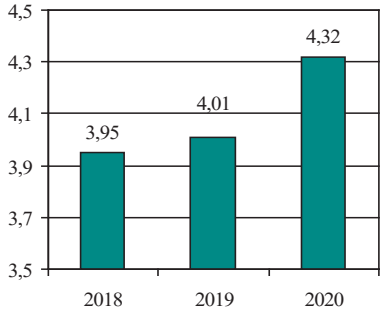

Figure 2. The dynamics of fat percentage per years

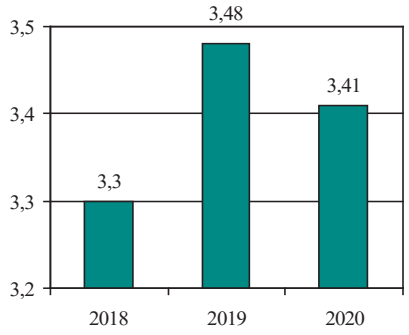

Figure 3. The dynamics of the protein percentage per years

The percentage of protein and the percentage of fat are parameters with high importance. It can be seen that the fat/protein ratio is normal, both for the 2018/2019 and 2019/2020 comparisons, and as a percentage, both characters are within the limits of the breed.

Another analysed parameter was the somatic cell count, which has major implications in udder health. Its average values show that the udder health of the studied animals is good (Figure 4).

An ascending evolution of the somatic cells count can be observed from year to year, but this fact can be attributed to the reaching of the cow's productive maturity, and the values remained within normal limits.

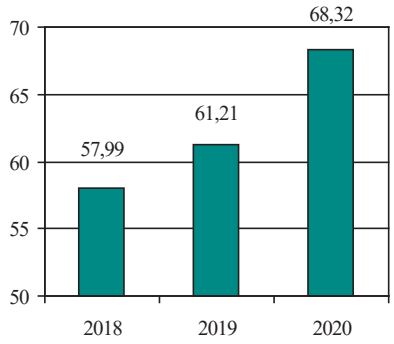

Figure 4. The dynamics of SCC per years

The increase of the dry matter percentage, as can be seen from the graphic representation, is higher from one year to another, due to the increase in the amount of milk (Figure 5).

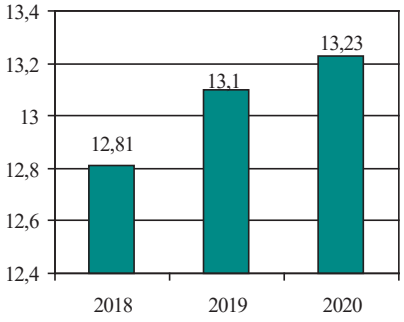

Figure 5. The dynamics of the percentage of dry matter per years

The comparative analysis of the 3 years of production shows that from one year to another, the Holstein cows' herd had a positive evolution, which was seen both in the quantity of milk and in its quality.

2. Testing the results for significance of differences

In the case of experimental research, there were compared the recorded performances throughout the analysed period, 2018-2020, using the Fisher and Student test.

In order to determine whether or not there were significant differences in milk quantity from year to year for the period 2018-2020, there was calculated Fisher's test with analysis of variance.

In Table 3 it can be observed that the calculated Fisher value is much higher than the tabulated Fisher value for the corresponding degrees of freedom. Thus, analysing the value of P, it can be concluded that for the amount of milk there are very significant differences between the 3 years of production, for Holstein cows.

Table 3. Fisher's test by Analysis of Variance (ANOVA) for homogeneity of variances in milk quantity

Source of variation	DF	SS	MS	$\hat{F}$ calculated	P value	$\hat{F}$ tabulated
Between groups	2	14566.92	7283.46	191.70	0.001	2.99
Within groups	4987	189474.10	37.99	-	-	-
Total	4989	204041	-	-	-	-

DF – degrees of freedom;
SS – sum of squares;
MS – mean of squares.

Because the Fisher test provides information only at general level, that is there are significant differences between the 3 years of production, further the Student test was applied to check if the differences are only for certain years of production (Table 4).

Table 4. Student test for milk quantity

Specification	2018/2019	2018/2020	2019/2020
t-calculated	10.45	21.68	10.43
t-table	1.96	1.96	1.96
p value	0.001	0.001	0.001

Thus, all possible combinations between the 3 years were taken into account in order to establish if there are statistical differences between them.

As expected, and supported by the Student's test, it can be observed that P values are all adequated to the highest degree of significance, namely that there are very significant differences for all combinations of the 3 years of production.

Following, all 4 qualitative milk parameters were analysed and, as it is shown in Table 5, for fat percentage the differences are very significant (p - 0.001).

Table 5. Fisher's test by Analysis of Variance (ANOVA) for homogeneity of variances for % of milk fat

Source of variation	DF	SS	MS	$\hat{F}$ calculated	P value	$\hat{F}$ tabulated
Between groups	2	136.30	68.15	113.70	0.001	2.99
Within groups	4987	2988.90	0.59	-	-	-
Total	4989	3125.25	-	-	-	-

DF – degrees of freedom;
SS – sum of squares;
MS – mean of squares.

When one year was compared with another, using the Student's test, it was found that for the combination between 2018 and 2019 the differences were distinctly significant (p - 0.02), and for the other two combinations, 2018 with 2020 and 2019 with 2020, the differences were very significant (p - 0.001) (Table 6).

Table 6. Student's test for milk fat values

Specification	2018/2019	2018/2020	2019/2020
t-calculated	2.20	13.77	12.29
t-table	1.96	1.96	1.96
p value	0.02	0.001	0.001

Analysing the protein percentage from the variances homogeneity point of view, between the years 2018, 2019 and 2020, it can be found that, as in the case of the fat percentage, the differences also show that they are very significant (p - 0.001) (Table 7).

Table 7. Fisher's test by Analysis of Variance (ANOVA) for homogeneity of variances for % of milk protein

Source of variation	DF	SS	MS	$\hat{F}$ calculated	P value	$\hat{F}$ tabulated
Between groups	2	25.32	12.66	67.91	0.001	2.99
Within groups	4987	929.60	0.18	-	-	-
Total	4989	954.92	-	-	-	-

DF – degrees of freedom;
SS – sum of squares;
MS – mean of squares;

In Table 8 it can be observed that when the years are analysed in groups of two, there is a slight change in the relevance of milk protein.

Table 8. Student's t test for milk protein values

Specification	2018/2019	2018/2020	2019/2020
t-calculated	11.97	7.86	3.92
t-table	1.96	1.96	1.96
p value	0.001	0.01	0.01

Thus, for the percentage of protein, the Student test shows that there are very significant differences when we compare the years 2018 with 2019. When comparing 2018 with 2020 and 2019 with 2020, the differences are only distinctly significant.
As a general conclusion, there are statistically significant differences between the 3 years of production, regardless of how they are evaluated.
Table 9 shows that for the parameter with major importance in udder health (somatic cells count - SCC) there are very significant differences between the 3 years in which Holstein cows were analysed and evaluated.

Table 9. Fisher's test by Analysis of Variance (ANOVA) for checking homogeneity of variances for SCC

Source of variation	DF	SS	MS	$\hat{F}$ calculated	P value	$\hat{F}$ tabulated
Between groups	2	86527.59	43263.79	19.67	0.001	2.99
Within groups	4987	10963623	2198.44	-	-	-
Total	4989	11050151	-	-	-	-

DF – degrees of freedom;
SS – sum of squares;
MS – mean of squares.

Although the Fisher test, through the analysis of variance, showed that there are very significant statistical differences between the values of the somatic cells count from one year to another, when the evaluation is done by groups (Table 10), the differences are distinctly significant (with a p value between 0.01 and 0.04).

Table 10. Student's t-test for SCC

Specification	2018/2019	2018/2020	2019/2020
t-calculated	2.04	5.94	4.43
t-table	1.96	1.96	1.96
p value	0.04	0.01	0.01

The last character analysed (dry matter, %), but not the last one in terms of importance, shows that when the 3 years are analysed at the same time, the statistical differences are very significant (Table 11).
The data obtained after the statistical analysis by comparing the years two by two, show that for the combination of 2018-2019 and that of 2019-2020, the differences were distinctly significant, and for the years 2018-2020 very significant statistical differences resulted (Table 12).

Table 11. Fisher's test by Analysis of Variance (ANOVA) for checking homogeneity of variants for % of milk dry matter

Source of variation	DF	SS	MS	$\hat{F}$ calculated	P value	$\hat{F}$ tabulated
Between groups	2	133.86	66.93	61.06	0.001	2.99
Within groups	4987	5465.98	1.09	-	-	-
Total	4989	5599.85	-	-	-	-

DF – degrees of freedom;
SS – sum of squares;
MS – mean of squares.

Table 12. Student's t-test for % milk dry matter

Specification	2018/2019	2018/2020	2019/2020
t-calculated	7.79	11.13	3.85
t-table	1.96	1.96	1.96
p value	0.01	0.001	0.01

From the analysed data, related to the quantity and quality parameters of milk, it can be observed that the measures and decisions that were taken every year at the farm level, in terms of selection, nutrition and management, led to significant changes in milk quality.

CONCLUSIONS

Milk production increased significantly by performing three milking per day, compared to the milking technology based on two milking per day.

All quality parameters taken into account (fat percentage, protein percentage, dry matter percentage and somatic cells count) of the milk have improved. Even if there are increases in the values of somatic cells count, this fact has nothing to do with the health of the udder, but is correlated with reaching the productivity maturity of the cows.

Milk production, both quantitative and qualitative, is critically influenced by the genetic value of the animals and the feeding technology, but also by the milking technology, which can be improved (udder preparation, daily number of milkings, interval between milkings etc.).

The transition to three milking per day had a positive impact both on milk production and on the animals in general. In order to increase milk production and a good state of health of the animals, it is recommended to continue milking the dairy cows three times a day, thus ensuring appropriate conditions for breeding and exploitation.

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