Effects of Farm Size on Milk Production Indices in Romanian Spotted Cows from Hunedoara County

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Abstract

Researches were carried out on 1707 Romanian Spotted cows raised in farms from Hunedoara County that were enrolled in official performance control scheme. According to the number of milking cows (farm size), farms were divided into three categories small (n≤10 cows), middle (n=11 to 25 cows) and large (n>25 cows). The influence of the farm size on the daily milk yield and milk components (fat, protein, casein and lactose) was determined by using ANOVA, and lactation curve was drawn using the gamma incomplete function. Generally, the farm size had a significant influence on all studied milk indices ($p<0.01$). For the daily milk yield and fat percentage, the highest values were obtained in the small farms (25.50 kg milk with 3.82% fat), followed by the large farms (23.45 kg milk with 3.76% fat) and the middle farms (21.46 kg with 3.69% fat). For protein percentage and casein content, the highest values were obtained in middle farms (3.32% protein and 25.66 g/L casein) followed by small farms (3.27% protein and 25.41 g/L casein) and large farms (3.25% protein and 25.58 g/L casein). The highest values for milk lactose percentage were obtained in large farms (4.81%) followed by middle and small farms (4.78% and 4.76%, respectively). In conclusion, we can state that the farm size had an influence on daily milk yield and its chemical components, due to feeding and housing technologies employed in those farms. Small farms had the highest daily milk yield and fat percentage, middle farms' milk was higher in protein and casein content, while large farms had the highest lactose percentage in the milk.

Keywords: cows, daily milk yield, farm size, milk chemical composition, Romanian Spotted.

1. Introduction

Milk production is the main selection criterion for dairy and dual-purpose cows, enabling to rank the animals in order to create the selection nucleus, and to be able to nominate the candidate cows and bull dams [1].

Knowing how the farm size is influencing the milk yield, as well as the milk quality, is the background condition for high milk production with high biological and hygienical value [2].

Dynamics of the lactation is determined by the physiological factors that cow is going through after calving. Dairy cows with flatter lactation curve have a higher persistency in milk compared with cows with the same milk production but shaper lactation curve [3].

For the dairy cows having a flatter lactation curve the incidence of metabolic and reproduction disorders are lower, reducing the production costs. Knowing the shape of the lactation curve in dairy cows allow the farmer to adapt the diet to animals, to obtain the optimal nutrition according to the daily milk production [4].

The aim of this paper was to highlight the effect of the farm size on some daily milk production indices during lactation, for one year, in Romanian Spotted cows from Hunedoara County. Also, we have studied the lactation curve for milk and milk

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chemical components, during normal lactation, according to farm size.

2. Materials and methods

Studies were carried out on 1707 Romanian Spotted cows raised in farms from Hunedoara County that were in the official performance control scheme.

According to the number of cows (farm size), the farms were divided into three categories: small (less or equal to 10 cows, n=572 heads), middle (between 11 and 25 cows, n=689 heads), and large (over 25 cows, n=446 heads).

The official performance control was done according to the National Authority legislation, respecting the official methodology (OM nr. 19/2006), updated and agreed by the international competent organization (ICAR).

During the test day, the milk from each cow was weighed, and milk samples were collected for qualitative control. Sampling was carried out using an on-line sampler, either a graduated pipette, after good homogenization of the whole milk from that milking.

The volume of the sample (at least 25 mL) was proportional with the amount of the milk from that milking. The milk samples were analysed for chemical composition at the laboratory agreed by the National Authority, for fat percentage, protein percentage, casein content and lactose percentage.

Test day data were statistically analysed using STATISTICA software, the ANOVA/MANOVA procedure [5]. Effects of farm size on the test day milk yield and components (fat percentage, protein percentage, casein content, and lactose percentage) was determined.

The incomplete gamma function [6] was applied to the database to obtain the lactation curve for each studied milk production indicator.

3. Results and discussion

If the genetic determinants of the lactation curves would be determined, a mathematical model could be elaborated to help cow selection by lactation persistency that could improve the economic efficiency in dairy cow production [7].

Table 1 presents the averages, dispersion indices and statistical significance for test milk yield, for the 13 controls, along one calendar year, according to the farm size.

From the Table 1 one can see at the first control, as well as at the last control (control 13) of the year, the farm size had no effect on the daily milk yield, differences among the farm categories, were small and statistically non-significant ($p>0.05$). Also, small and non-significant differences were observed between small and middle farms at controls no. 2, 4, 6, and 12, as well as between middle and large farms at controls no. 3 and 11.

All the other comparisons were statistically significant ($p<0.01$ or <0.001), showing that, generally there was a significant influence of the farm size of the daily milk yield at the control day in Romanian Spotted cows.

Generally, the daily milk yield was higher in large and middle size farms compared to small farms.

Table 1. Average (kg/day), standard error of the mean and statistical significance for daily milk yield on test day according to the farm size

Control	Farm size			Significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
1	16.03± 0.21	15.73± 0.17	15.48± 0.24	ns	ns	ns
2	15.92± 0.20	15.73± 0.17	18.82± 0.37	ns	***	***
3	15.86± 0.21	16.31± 0.18	16.11± 0.24	**	**	ns
4	16.39± 0.21	16.71± 0.18	18.93± 0.40	ns	***	***
5	16.96± 0.20	17.42± 0.19	19.41± 0.44	**	***	***
6	17.39± 0.20	17.70± 0.02	20.53± 0.19	ns	***	***
7	16.99± 0.20	18.14± 0.17	17.75± 0.16	***	***	***
8	16.14± 0.19	16.93± 0.16	21.44± 0.34	**	***	***
9	15.87± 0.19	16.84± 0.17	16.40± 0.22	***	***	**
10	15.43± 0.20	15.95±0.17	19.36± 0.30	**	***	***
11	14.98± 0.22	15.98± 0.22	15.85± 0.22	***	***	ns
12	16.37± 0.71	16.00± 0.61	20.79± 0.69	ns	***	***
13	15.87± 0.21	15.46± 0.17	15.44± 0.22	ns	ns	ns

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

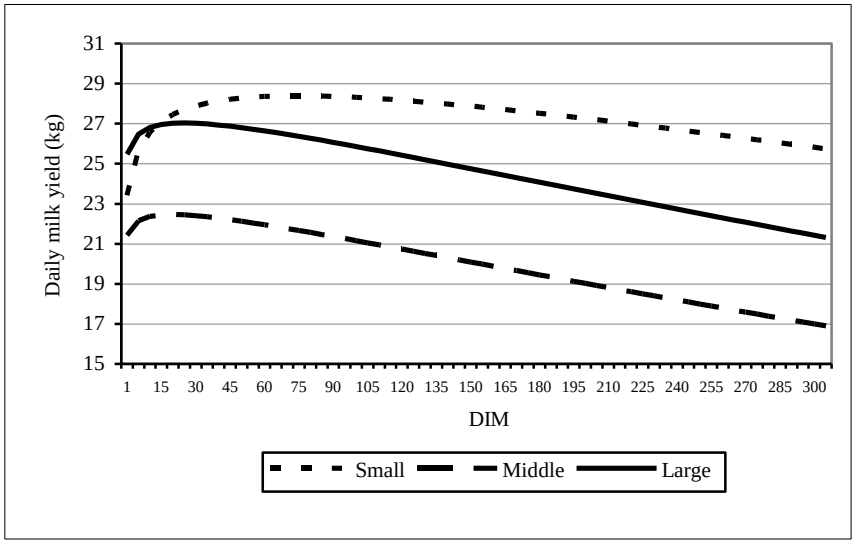

Figure 1. Lactation curve for daily milk yield in Romanian Spotted cows, by farm size, after applying the incomplete gamma function

Figure 1 presents the lactation curves for the three farm categories (small, middle, and large), after modeling with incomplete gamma function, per normal lactation (during the first 305 DIM). All three lactation curves had an ascending phase, a descending phase as well as a short plateau phase. For middle and large farms, the lactation curve was flatter, and the shapes were very similar, while for small farms the ascending phase was steeper, but the descending phase was flatter than in the other two farm categories.

Averages, dispersion indices and statistical significance for fat percentage, by farm size, are presented in Table 2. Generally, with small exceptions, the farm size had a significant effect ($p<0.05$) on milk fat percentage in Romanian Spotted cows. The only stages of lactation when an influence of farm size on fat percentage was not detected ($p>0.05$) were the controls 5 and 7. Also, at controls 8 and 9 the fat percentage were similar ($p>0.05$) between middle and small farms, and between middle and large farms, respectively.

Table 2. Average (%), standard error of the mean and statistical significance for milk fat percentage according to the farm size

Control	Farm size			Significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
1	4.20± 0.04	4.18± 0.03	4.45± 0.04	*	***	***
2	3.80± 0.04	3.70± 0.03	3.99± 0.04	***	***	***
3	3.94± 0.03	3.86± 0.03	4.31± 0.05	***	***	***
4	3.72± 0.03	3.57± 0.03	3.85± 0.04	***	***	***
5	3.83± 0.04	3.85± 0.03	3.89± 0.04	ns	ns	ns
6	3.63± 0.03	3.78± 0.03	3.60± 0.03	**	*	**
7	3.57± 0.03	3.57± 0.03	3.60± 0.04	ns	ns	ns
8	4.02± 0.04	4.03± 0.04	3.70± 0.03	ns	***	***
9	3.95± 0.04	3.88± 0.03	3.87± 0.03	*	*	ns
10	4.26± 0.04	4.03±0.03	3.83± 0.03	***	***	***
11	4.50± 0.05	4.22± 0.04	4.13± 0.04	***	***	***
12	4.31± 0.20	5.38± 0.71	3.67± 0.06	***	***	***
13	4.42± 0.05	4.26± 0.04	4.16± 0.07	**	**	**

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

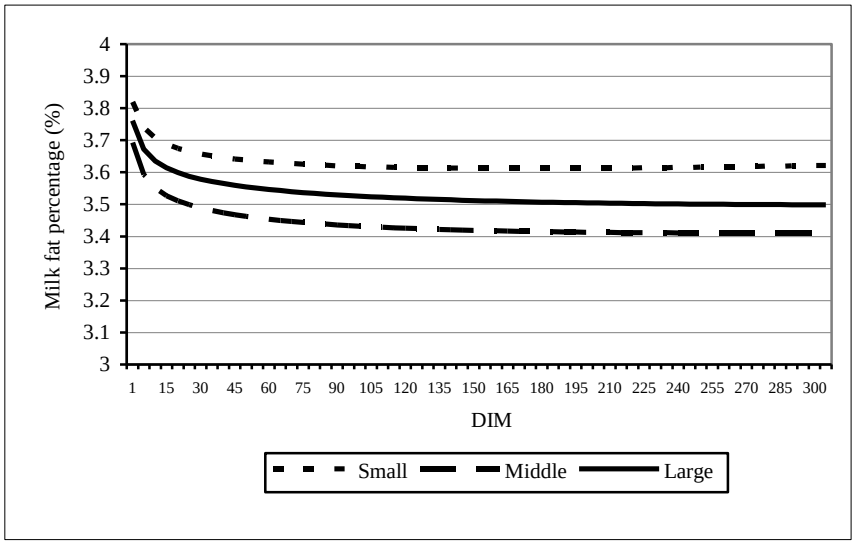

Figure 2. Lactation curve for milk fat percentage in Romanian Spotted cows, by farm size, after applying the incomplete gamma function

Regarding the dynamics of the fat percentage during lactation (Figure 2), the shape of the lactation curves for all three farm sizes was approximately the same. There was decrease of fat percentage during the first three months after calving from 3.70-3.87% at the beginning of lactation to 3.4-3.62% and these values were maintained until the end of lactation. The highest milk fat percentage, after modeling, was observed in small farms, followed by large farms, and the lower values were observed in middle farms.

Table 3 presents the averages, dispersion indices, and statistical significance for milk protein percentage, according to farm size, for all 13 controls during a calendar year, resulted from the performance recording scheme in Hunedoara County.

Data in Table 3 shows very clearly that the farm size had a significant influence on milk fat percentage, in most controls during lactation there was a very significant difference ($p<0.001$) among farm sizes. Exception, was control 10, where the value for milk protein percentage was the same (3.87%, $p>0.05$) in all three farm size groups. Differences between protein percentage in small and middle farms at control 1 and middle and large farms at control 6, did not attained statistical significance ($p>0.05$), as well.

Table 3. Average (%), standard error of the mean and statistical significance for milk protein percentage according to the farm size

Control	Farm size			Significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
1	3.58± 0.01	3.58± 0.01	3.93± 0.02	ns	***	***
2	3.34± 0.01	3.45± 0.01	3.77± 0.02	***	***	***
3	3.29± 0.01	3.32± 0.01	3.68± 0.02	***	***	***
4	3.24± 0.01	3.27± 0.01	3.60± 0.02	***	***	***
5	3.50± 0.01	3.46± 0.01	3.60± 0.02	***	***	***
6	3.80± 0.01	3.84± 0.01	3.84± 0.01	**	**	ns
7	3.73± 0.01	3.74± 0.01	3.84± 0.01	***	***	***
8	3.76± 0.01	3.75± 0.01	3.80± 0.02	**	***	***
9	3.75± 0.01	3.72± 0.01	3.79± 0.01	***	***	***
10	3.87± 0.01	3.87± 0.01	3.87± 0.01	ns	ns	ns
11	3.95± 0.01	3.92± 0.01	4.06± 0.01	***	***	***
12	3.77± 0.01	3.81± 0.01	3.97± 0.02	***	***	***
13	3.63± 0.01	3.67± 0.01	4.07± 0.01	**	**	**

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

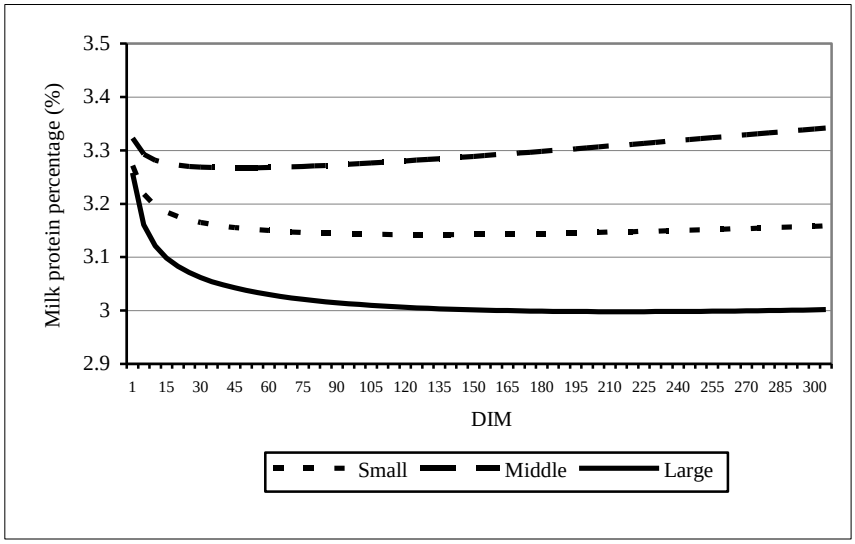

Figure 3. Lactation curve for milk protein percentage in Romanian Spotted cows, by farm size, after applying the incomplete gamma function

Lactation curves for protein percentage in milk, after using the gamma incomplete function on database, are shown in Figure 3. The highest mil protein percentage throughout the lactation was observed in middle farms, followed by small farms and then the large farms. The highest reduction of protein percentage was observed in large farms, leading to a steeper lactation curve in cows from these farms.

Casein is a complex protein from milk. It represents about 80% of all milk proteins [7]. When human body identifies the casein as being a harmful protein, the immunity system activates the specific antibodies, the type E immunoglobulin (IgE), releasing the histamine, causing inflammations at tissues level.

Table 4 presents the averages, dispersion indices and statistical significance for casein content of milk according to the farm size. Generally, the farm size had a significant influence on the casein content of cow milk, varying largely from control to control, and among the three farm size groups ($p<0.05$).

Table 4. Average (g/L), standard error of the mean and statistical significance for milk casein content according to the farm size

Control	Farm size			Significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
1	28.21± 0.15	28.18± 0.15	28.19± 0.15	***	***	***
2	26.37± 0.12	27.27± 0.14	29.73± 0.12	***	***	***
3	26.01± 0.14	26.20± 0.11	28.79± 0.18	***	***	***
4	25.45± 0.12	25.68± 0.10	28.18± 0.12	***	***	***
5	27.46± 0.14	27.20± 0.11	28.08± 0.17	***	***	***
6	29.62± 0.15	30.29± 0.10	30.36± 0.15	***	***	***
7	29.05± 0.13	29.14± 0.12	30.03± 0.15	***	***	***
8	29.43± 0.14	29.33± 0.10	29.82± 0.16	*	**	**
9	29.32± 0.14	29.11± 0.10	29.47± 0.17	*	*	**
10	30.54± 0.14	30.55± 0.11	30.52± 0.17	ns	ns	ns
11	31.41± 0.18	31.13± 0.18	32.37± 0.17	***	***	***
12	30.76± 0.79	30.54± 0.90	31.67± 0.23	ns	ns	ns
13	28.30± 0.22	28.90± 0.15	32.12± 0.32	***	***	***

ns = $p>0.05$, $p\leq0.05$*, $p<0.01$**, $p<0.001$***

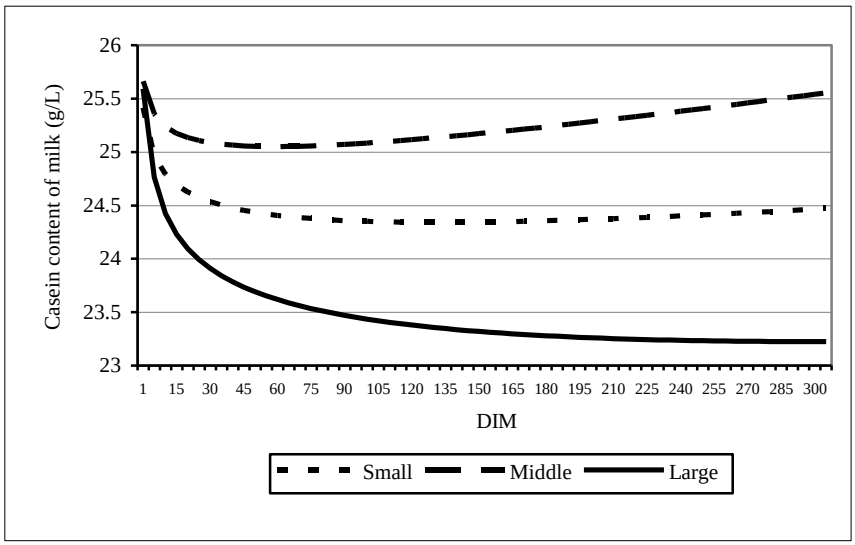

Figure 4. Lactation curve for milk casein content in Romanian Spotted cows, by farm size, after applying the incomplete gamma function

In controls 10 and 12 the values for casein content of milk were close among the farm size groups, therefore the differences were not statistically significant ($p>0.05$).

Figure 4 shows a relatively high difference among farm size groups regarding the shape of the lactation curve for casein content in milk, during a normal lactation. This the highest drop in casein content, from 25.6 g/L to 23.5 g/L, during the first 3 months of lactation was observed in large farms. Also, in these farms the casein content continues to decrease until the end of lactation, to a value of 23.2 g/L.

The highest casein content was observed in middle farms, that had 25.7 g/L at the beginning of lactation that drops to about 25 g/L during the first month of lactation and increase again to 25.6 g/L at the end of lactation. Cows in small farms had a flatter lactation curve for casein content in milk.

Lactose is a sugar from milk and milk products. It represents about 30% from the caloric contribution of the milk [1]. Lactose content of the milk could vary between 1% and 7% according to the milk provenience [8,9].

Averages, dispersion indices and statistical significance for lactose percentage in milk according to the farm size are presented in Table5. There was observed a significant influence ($p<0.05$) of the farm size on the lactose percentage of milk from one control to another, except for controls 5 and 7, where small differences were obtained among farm sizes and the differences were not statistically assured ($p>0.05$).

The dynamics of lactose percentage in milk along the lactation is presented in Figure 5. Along the whole lactation, the highest lactose percentage was observed in large farms. Although at the start of lactation the lactose percentage was smaller than in other groups, lactose percentage continues to steadily increase until the end of the normal lactation. On the opposite site, in cows from small farms the lactose percentage was very high at the beginning, a abrupt decrease was observed during the first 60 days of lactation, and continues to decrease until the end of lactation. For the middle farms, the lactose percentage was not that high at the beginning of lactation, abruptly decreased in the first month after calving, reaching a plateau between 60 and 120 days of lactation, then increasing again until de end of lactation.

4. Conclusions

Farm size had a significant influence on the milk production indices: milk yield in the test day, fat percentage, protein percentage, casein content and lactose percentage.

There was a great variation of milk production indices by test day, as well as by farm size group.

Modeling the test day milk indices by using the incomplete gamma function helped to better visualize the differences among the farm size groups.

Table 5. Average (%), standard error of the mean and statistical significance for milk lactose percentage according to the farm size

Control	Farm size			Significance		
	Small	Middle	Large	Small vs. Middle	Small vs. Large	Middle vs. Large
1	4.51±0.02	4.54±0.01	4.52±0.03	***	*	**
2	4.66±0.02	4.67±0.01	4.56±0.03	**	***	***
3	4.47±0.01	4.51±0.01	4.52±0.01	***	***	**
4	4.52±0.01	4.55±0.01	4.62±0.01	***	***	***
5	4.53±0.01	4.52±0.01	4.53±0.01	ns	ns	ns
6	4.75±0.01	4.68±0.01	4.72±0.01	***	***	***
7	4.67±0.01	4.67±0.01	4.68±0.01	ns	ns	ns
8	4.65±0.01	4.63±0.01	4.72±0.01	***	***	***
9	4.58±0.01	4.60±0.01	4.64±0.01	***	***	***
10	4.53±0.01	4.47±0.01	4.60±0.01	***	***	***
11	4.53±0.01	4.50±0.01	4.58±0.02	***	***	***
12	4.46±0.07	4.41±0.03	4.72±0.02	***	***	***
13	4.48±0.02	4.40±0.02	4.36±0.03	***	***	***

ns = p>0.05, p≤0.05*, p<0.01**, p<0.001***

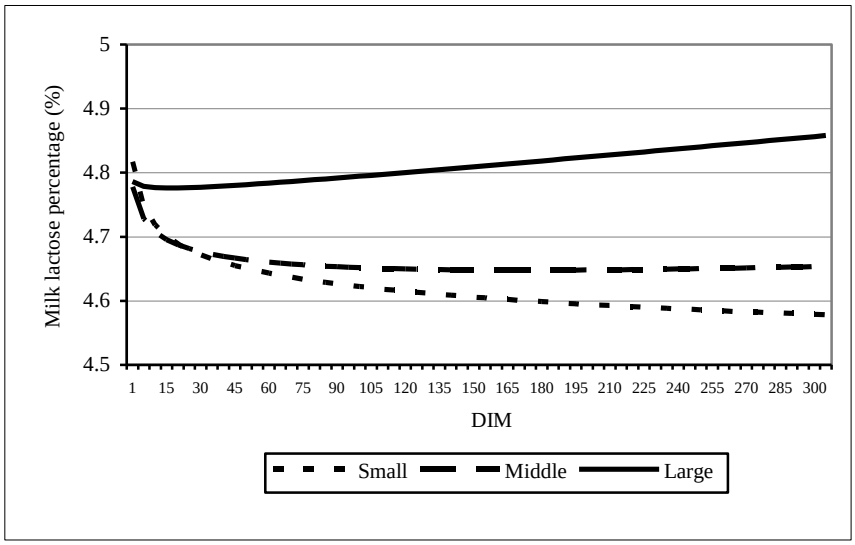

Figure 5. Lactation curve for milk lactose percentage in Romanian Spotted cows, by farm size, after applying the incomplete gamma function

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