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# Secreted Colostrum Volume, Transition and Mature Milk Outputs After Calving in Holstein Friesian Cows

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**Abstract:** Colostrum volume after calving, transition and mature milk outputs in the time from 1<sup>st</sup> to 10<sup>th</sup> milkings were evaluated at 30 primiparous and 30 multiparous cows milked twice daily. Colostrum volume at the first milking after calving varied from 1.5 to 19.2 kg (mean 9.44 ± 5.6 kg SD) in multiparous and from 1.2 to 9.8 kg (mean 5.65 ± 2.3 kg SD) in primiparous cows. Timing of the first milking did not negatively influence colostrum volume. Colostrum volume of the second milking decreased over all multiparous and primiparous cows because the period of time between first and second milking was shorter (10.5 hours). The hourly milk outputs increased sharply from the second to the fourth milking in multiparous and primiparous Holstein Friesian cows. Applying a linear regression model we observed a significant large positive relationship between volume of colostrum at first milking and subsequent transition and mature milk outputs from 2<sup>nd</sup> to 10<sup>th</sup> milkings. A low colostrum volume secreted was identified in multiparous cows, as a result of shorter dry period and in primiparous cows, probably as a result of low secretory capacity of mammary gland. Extended feeding with transition milk can be real health benefits for the newborn calf.

**Keywords:** Colostrum Volume, Transition Milk, Mature Milk, Time Between Milkings

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## 1. Introduction

Colostrum volume and quality of the first milking vary distinctly between cows, herds and region [1, 2] furthermore between quarters of the mammary gland within cows [3-5]. In previous studies it is showed that large variation of colostrum volume and its distribution in quarters exist in consecutive lactations of cows [5, 6].

During the established lactation, the hind quarters showed to produce more milk compared with the front quarters [5, 7, 8].

Some publications showed that volume of colostrum produced at first milking has been negatively correlated with IgG concentration as a result of dilution effect [9, 10]. IgG class is the main immunoglobulin transferred from the Dam to the newborn calf via colostrum. IgGs from the blood flow of Dam enter in the extracellular fluid and receptors on mammary epithelial cells catch IgGs, and by endocytosis and transport are delivered into lumen secretions.

Immunoglobulins locally produced by plasmacytes in the mammary secretions are IgA and IgM classes [11, 10].

In addition colostrum is the primary nutrient source for the newborn calf [10]. Bovine colostrum has a higher total protein (immunoglobulin and casein) content than mature milk (about 15% versus 3%).

The casein content is considered as an energy source and a factor with immune-regulatory, antibacterial and anti-inflammatory characteristics [13].

Lactose is the principal saccharide in bovine colostrum (about 2.5%). Bovine colostrum contains about 7% fat (milkfat globules) and lipid fraction with components of potential health relevance [14, 15]. Also bovine colostrum has fat-soluble A, D, E vitamins and water-soluble (B-complex) vitamins and are higher in concentrations than in mature milk. Colostrum is rich in essential minerals (calcium, copper, iron, zinc, magnesium, manganese and phosphorus) [16].

Soufleri et al., (2021) [17] reported a range of colostrum yield from 0.5 to 23.5 kg (average 6.2 kg and a coefficient of

variation of 61%). The deficiency in colostrum production was reported in Jersey cows with more than one lactation from June to December compared to first colostrum of primiparous cows [18].

They reported an average colostrum volume of 6.6 kg/cow in June 2016, 2.5 kg/cow in December 2016 and 4.8 kg/cow in May 2017.

Dry period extend, calf sex, age at freshening, month of parturition and previous lactation duration were associated with probability of low colostrum volume <2.7 kg at first milking [18].

Physiochemical characteristics of colostrum and milk in ruminants maybe modified by different nutrition programs during the dry period [2, 19]. A rational nutrition in the dry period and lactation periods means using high quality feeds, correct concentration of nutrients in feed rations, and satisfying cows' protein and energy, nutritional needs, and balancing mineral and vitamin content of diet rations.

Some previous studies suggest that natural antibodies (part of the innate immune system) in the colostrum and calf semen can be increased by genetic selection [20-22].

Genetic traits of colostrum in Holstein cows were estimated by Soufleri et al., 2019 [12]. They reported heritability estimates for total solids, fat, protein, lactose, energy contents and colostrum yield of 0.27, 0.21, 0.19, 0.15, 0.22 and 0.04 respectively, based on Brix refractometer measurements. This results suggest that these traits can be improved by genetic selection.

Selection for traits with the same heritabilities like milk yield (0.2-0.5) and milk somatic cell count (0.03-0.11) is, at present, used in breeding programs.

Colostrum total solids (TS) is positive correlated with colostrum energy content [20] and selection for increasing TS content in colostrum can improve also energy content of colostrum.

Phenotypes can be identified by using Brix refractometer, which is a reliable tool for indirect determination of the immunoglobulin concentration in milk and in calf blood serum.

The transition phase, defined as the period between 21 days before to 21 days after calving, is a critical period in relation with health status of the cows. Metabolic disorders are disturbance of one or multiple metabolic processes and can occur slowly or abruptly in the transition phase when the difference between nutrient and energy request and their provision is limited. The metabolic disorders affect cow's lactation performance, fertility and longevity.

Transition milk is the milk that is produced during the 2<sup>nd</sup> to the 6<sup>th</sup> milking after calving, and is an intermediate between colostrum and whole milk. Pots, (2022) [23] reported that milk from second milking can contain 30% more fat, 170% more protein, 15% more calcium, 458% more vitamin A, and 406% more vitamin E than whole milk. Also, milk from 3<sup>rd</sup> milking can contain 65% more protein, 15% more calcium, 232% more vitamin A and 273% more vitamin E than whole milk.

Whole milk or mature milk is the milk produced beyond 8<sup>th</sup> milking. Amount of colostral IgG is considered as the most factor for colostrum quality, but progress in proteomics (large-scale analysis of proteins) identified additional milk proteins with bioactive characteristics for newborn calf [24-26].

Hansen et al. (2006) [27] showed that accelerating pattern of milk produced after calving is related to development of health problems as a result of metabolic stress. Thus, selection for suitable colostrum, for passive transfer of immunity and at the same time for provide optimal nutrients for the newborn calf can be a good option for the improvement of quantity and quality of colostrum and transition of mammary secretions. The objectives of this study was to evaluate the variation of colostrum volume and transition milk output in the first day of calving and their associations with the whole milk output.

## 2. Materials and Methods

This study was done in the Research dairy Farm of Agricultural Research and Development Station (ARDS) Simnic-Craiova, Romania (182 m above sea level 4°19' N, 23°48' E).

Primiparous (n= 30) and multiparous (n= 30; 3.6 ± 0.4 parities; mean ± SD) were monitored during the entire lactations. The milk yield of the previous standard lactations (305 days) of the multiparous cows was 9219 ± 430 kg. Dairy cows and heifers are housed in barns with access to dry-lot, prepartum and postpartum, and were fed in the morning and afternoon with diets formulated to meet or exceed nutritional requirements for dry and lactating dairy cows. Additionally, all cows and heifers have access to pasture (alfalfa or ryegrass).

In this study multiparous cows were milked for the first time 1 hour and 40 minutes ± 35 minutes and primiparous cows 2 hour and 10 minutes ± 30 minutes after parturition. The time interval between the first and the second milking after parturition was 10 hours and 30 minutes. From the second milking after parturition onwards, cows were milked twice daily at the scheduled milking time 05:00 and 17:00 h in the milking parlor. Milk yields of individual a.m. and p.m. milkings as well as daily milk yield were recorded. Ten milkings were evaluated from April 20 to June 30 2021 1<sup>st</sup> = colostrum volume (density 1.060); 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> = transition milk (density 1.040); 7<sup>th</sup>, 8<sup>th</sup>, 9<sup>th</sup>, 10<sup>th</sup> = mature milk (density 1.030).

The data were entered into M.E. computer program 2007. Stata Version 14 was used to summarize the data and descriptive statistics were used to express the results. The gradual gain of transition and mature milk during the first 10 milkings of multiparous and primiparous cows was compared. Hourly milk produced was calculated as milk output divided by the interval time between milkings.

The strength and direction of the relationship between variables were determined using CORR procedure of S.A.S.

### 3. Results

Colostrum volume at first milking after calving ranged

from 1.5 to 19.2 kg (liters x 1.060) (average  $9.44 \pm 5.6$  kg SD = standard deviation) in multiparous, and from 1.2 to 9.8 kg (average  $5.65 \pm 2.3$  kg SD) in primiparous cows (table 1).

**Table 1.** Descriptive statistics of colostrum volume at first milking and milk output at 2<sup>nd</sup> and 10<sup>th</sup> milkings.

Item	Multiparous cows			Primiparous cows		
	1 <sup>st</sup>	2 <sup>nd</sup>	10 <sup>th</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	10 <sup>th</sup>
Mean (kg)	9.44	8.69	16.52	5.65	5.04	11.21
Standard deviation (kg)	5.6	5.49	5.40	2.30	1.86	2.71
Median (kg)	8.7	8	16.50	6.05	5.20	12.30
Minimum (kg)	1.5	1.20	8.50	1.20	1.10	5.80
Maximum (kg)	19.2	18.80	25.40	9.80	8	14
Quartile 1 (kg)	5.25	4.20	11.40	4.70	4	9
Quartile 3 (kg)	12.75	11.55	18	8.60	6.30	13.30
Coefficient of variation (%)	59	63	33	41	37	24
Standard error of the mean	1.02	1.0	0.98	0.42	0.34	0.49

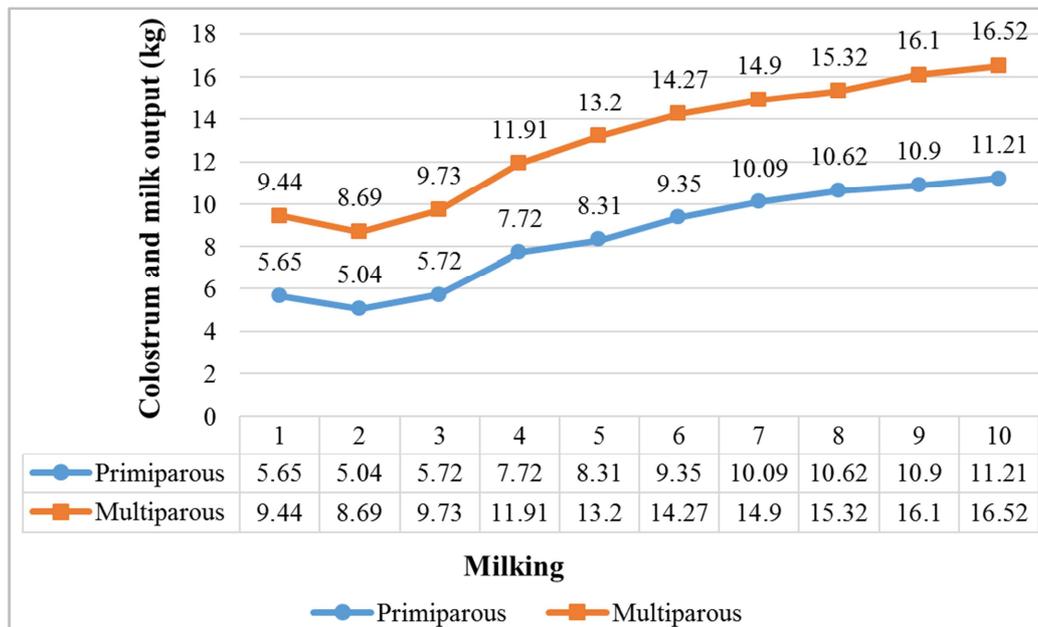
Multiparous and primiparous cows showed a large extend of colostrum volume at first milking. At the tenth milking extend of milk outputs was still present (table 1).

A larger dispersion of colostrum volumes produced at first milking was observed (coefficient of variation; CV = 59%) in multiparous cows compared with primiparous cows (CV = 41%; table 1). At second milking the colostrum volume decreased with 8% in multiparous cows and with 10.8% in primiparous cows, as a result of shorter time between first milking and second milking. In this study first milking was made at  $100 \pm 35$  minutes after calving in multiparous cows and at  $130 \pm 30$  minutes in primiparous cows. The second milking for all cows was made at 10.5 hours after first milking as the first scheduled milking time in the milking parlour. Beyond second milking time, all cows are milked

twice daily at 12 – hour intervals.

At second milking the largest dispersion of colostrum volumes was observed in multiparous cows (CV = 63%) compared with primiparous cows (CV = 37%). At tenth milking the CV of colostrum volume decreased at 33% in multiparous and 24% in primiparous cows (table 1). After second milking the milk output increased more alert until 5<sup>th</sup> milkings, and after that the rate of increase in milk output was reduced (figure 1).

The pattern of colostrum volume and milk output along the lactation is the result of physiological mechanism controlling the growth and development of mammary gland and the processes of Colostrogenesis and milk secretion. A standard shape of the lactation curve represent the phenotypic expression of all biological involved processes.



**Figure 1.** Lactation curves from first to 10<sup>th</sup> milking in primiparous and multiparous cows. Data are as mean values and the differences between primiparous and multiparous cows at each milking were statistically significant ( $p < 0.05$ ) and are showed as \* and ( $p < 0.01$ ) as \*\*.

Rate increase of milk produced by mammary gland in the first phase, time in peak development, peak output and the

rate of decline in the second phase are basic traits of a lactation curve.

**Table 2.** Hourly milk production (kg/h) from the 2<sup>nd</sup> to the 10<sup>th</sup> milking in cows.

Milking	Multiparous cows		Primiparous cows	
	Mean	SEM*	Mean	SEM*
2 <sup>nd</sup>	0.82	0.06	0.48	0.04
3 <sup>rd</sup>	0.84	0.04	0.48	0.03
4 <sup>th</sup>	0.99	0.03	0.64	0.04
5 <sup>th</sup>	1.10	0.05	0.69	0.04
6 <sup>th</sup>	1.18	0.05	0.78	0.03
7 <sup>th</sup>	1.24	0.04	0.84	0.03
8 <sup>th</sup>	1.27	0.03	0.88	0.03
9 <sup>th</sup>	1.34	0.04	0.91	0.02
10 <sup>th</sup>	1.37	0.04	0.93	0.03

\*SEM = Standard error of the mean

In this study the milk output increase by almost 52% and 65% in multiparous cows and primiparous cows respectively, from the second to the 5<sup>th</sup> milking. From the 5<sup>th</sup> milking to the 10<sup>th</sup> milking the milk output increased by 25% and 35% in multiparous cows and primiparous cows respectively. Also hourly milk secretion increased from second milking to the 5<sup>th</sup> milking (table 2), there after hourly of milk.

Secretion decreased, but still ascending to the 10<sup>th</sup> milking.

The hourly milk produced by multiparous cows was higher than of primiparous cows at each milking.

The results of the pearson correlation indicated that there is a significant large positive relationship between.

**Table 3.** Coefficient of variation and association of colostrum volume with each milk output from 2<sup>nd</sup> to 10<sup>th</sup> milkings.

Milking	Multiparous cows				Primiparous cows			
	n	CV	r	p-value	n	CV	r	p-value
2 <sup>nd</sup>	30	0.63	0.99	< 0.001	30	0.37	0.98	< 0.001
3 <sup>rd</sup>	30	0.58	0.94	< 0.001	30	0.37	0.98	< 0.001
4 <sup>th</sup>	30	0.48	0.90	< 0.001	30	0.32	0.98	< 0.001
5 <sup>th</sup>	30	0.44	0.87	< 0.001	30	0.3	0.97	< 0.001
6 <sup>th</sup>	30	0.41	0.84	< 0.001	30	0.29	0.96	< 0.001
7 <sup>th</sup>	30	0.37	0.80	< 0.001	30	0.27	0.95	< 0.001
8 <sup>th</sup>	30	0.36	0.73	< 0.001	30	0.26	0.93	< 0.001
9 <sup>th</sup>	30	0.33	0.70	< 0.001	30	0.25	0.92	< 0.001
10 <sup>th</sup>	30	0.33	0.68	< 0.001	30	0.24	0.84	< 0.001

n = number of animals/observations

CV = coefficient of variation

r = Pearson correlation

Colostrum volume with each milk output from second to 10<sup>th</sup> milkings in multiparous and primiparous cows (table 3).

In our study we identified some of the cows with low colostrum volume at first milking as a result of shorter dry period in multiparous cows, and probably as a lower secretory capacity of mammary epithelial cells in primiparous cows. Five primiparous cows and four multiparous cows were identified with lower colostrum volume (<2.7 L). Volume of first colostrum feeding is recommended to be 2.7 L in multiple colostrum feeding and 3.3 L in single colostrum feeding [28].

## 4. Discussion

Our analysis confirm the variation in first colostrum volume reported in previous investigations [5-6, 16]. Several factors such as parity of dam, length of the dry period, interval between parturition and first milking, were reported that affect colostrum quantity and quality [10, 17].

In the present study the first milking was made at 100 ± 35 minutes after calving in multiparous cows and 130 ± 30 minutes after calving in primiparous cows. In some previous studies first milking was performed between 0.3 and 24 hours after calving in multiparous cows [10, 17-18], and this timing of the first milking did not negatively influenced colostrum yield and IgG concentration up to 9 to 12 h post parturition [12, 29-31]. It is well documented that colostrum yield and

colostral immunoglobulin concentrations are grater in older compared with younger cows [4, 12, 30].

Colostrum yields of the second milking depend on the milking interval between the first and the second milking. In the study the decrease in colostrum yields from the first to the second milking over all multiparous and all primiparous cows can be explained by the short time interval between these milking (10.5 hours) and the residual colostrum in mammary glands after first milking do not account for more yield of the second milking at scheduled milking times.

From the second to the 5<sup>th</sup> individual milking milk production increased more alert in multiparous and primiparous cows (figure 1).

In this study milk at first milking represented the volume of secreted colostrum, milk at 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> milkings represented transition milk output and milk at 7<sup>th</sup>, 8<sup>th</sup>, 9<sup>th</sup> and 10<sup>th</sup> milkings represented mature milk.

A lower secreted colostrum volume in primiparous cows compared with that of the multiparous cows was previously reported by [29-30, 32] as a result of reduced development of mammary secretory cells.

In this study transition milk from 2<sup>nd</sup> to 6<sup>th</sup> milking increase as a result of rapid lactose accumulation into mammary gland [1, 33]. Around calving tight junction (*zonula occludens*) between adjacent epithelial cells become fully functional [34] and lactose remains in mammary gland. Also water enters into secretory vesicle and increase the milk

output [35].

The secretory activation or stage II lactogenesis is not complete before calving [35]; immature alveoli and mammary epithelial cells still exist at 1 day after parturition. At 7 days postpartum the increase in milk output is the result of the extended secretory capacity of mammary epithelial cells and of more numbers of alveoli totally activated, contributing to the milk secretion [36].

For the highest IgG it is recommended that colostrum to be milked within 3 hours after calving [37]. Some previous study showed that up to 9 to 12 hours post calving IgG from colostrum has a constant level [12, 29, 31, 37].

Some health benefits can be added to the newborn calf by extended feeding with transition milk, but new researchers are needed to make specific recommendations.

Research on the causes of low colostrum production in cows is limited. Some of the risk factors for low colostrum volume are: genetics, photoperiod, poor dry or pre-fresh dry matter intakes short dry or short close-up periods, mastitis infection, fescue toxicosis, nutrition.

Selection for suitable colostrum volume, for adequate passive transfer of immunity and at the same time to provide optimal nutrients for the newborn calf can be a good option. Also extended feeding with transition milk can add more health benefits to the newborn calves. To improve the colostrum quantity and quality for a long term vision proper selection criteria must be decided.

## 5. Conclusions

The volume of colostrum at first milking varied larger in multiparous cows than in primiparous cows.

Hourly milk transition and mature milk output increased more alert in multiparous cows compared with primiparous cows.

A significant large positive relationship was between volume of colostrum secreted and subsequent milk transition and mature milk outputs.

Genetic selection for moderate colostrum volume at first milking can be a good option for improvement of health status of cows with high milk production and for optimal colostrum quantity and quality.

Some of the cows were identified with suboptimal colostrum volumes for feeding their newborn calves. More research are needed to identify risk factors involved.

Extended feeding with transition milk can be a real health benefit for the newborn calf.

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