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Connection of milk flow curve to the somatic cell count in bovine milk

Abstract

The modern equipment introduction into cow milking created technical possibilities for studying the milk flow curve and for using the results in cattle selection. In preventing mastitis, besides curing, other parameters of the milk flow curve could be used preventively. Research showed that cows that had the milk flow curve with a short duration of increasing flow rate (dIFR≤0.40 min) and a larger quotient between the peak and down phase (QPD>1.20) had also the least somatic cell count in milk (LSCC = 3.47, and 3.30 respectively). Such relation is favourable because increasing the relation, the duration of quick and uniform milking extends, and the duration of peak flow rate shortens. That also show correlation coefficients which were between the logarithmic somatic cell count in milk (LSCC) on one hand and the peak flow rate (dPFR), that means the quotient of peak and down phase (QPD) on the other hand negative (r= -0.25** and –0.27**). Breeding-selective procedures could create bull fathers and mothers with the most desirable milk flow curve and the duration of certain milking phases, whereby the somatic cell count in milk would be the least. Therefore it would be necessary to define desirable proportions of the milk flow curve with a special attention to the cow's health udder.

Key Words: milk flow curve, somatic cell, health udder, cow

Zusammenfassung

Titel der Arbeit: **Die Milchflusskurve und ihr Zusammenhang mit dem somatischen Zellgehalt von Kuhmilch**

Forschungsarbeiten zur Milchflusskurve und ihre Nutzung bei der Selektion in der Rinderzucht finden in immer mehr europäischen Ländern ihre Anwendung. Die an 175 Holstein Frisian Kühen in Kroatien durchgeführten Untersuchungen zeigten Zusammenhänge zwischen der Milchflusskurve und der Anzahl somatischer Zellen in der Kuhmilch. Die kleinste Anzahl somatischer Zellen in der Milch (3,47, bzw. 3,30) wurde während der kurzen Dauer der Anstiegsphase (≤0,40 min) und dem hohen Quotienten zwischen der Plateau- und der Dauer der Abstiegsphase (>1,20) nachgewiesen. Das ist erwünscht, wobei möglichst die Dauer der Plateauphase verlängert und die der Abstiegsphase verkürzt werden sollte. Die ermittelten Korrelationskoeffizienten zeigen, dass sich durch züchterische Maßnahmen, einige Melkeigenschaften verbessern ließen, wobei mit einer Verlängerung der Plateauphase bei gleichzeiteger Verkürzung der Anstiegs- und Abstiegsphase (r = -0,25** und -0,27**), sich die Anzahl somatischer Zellen verringern ließe. Eine Berücksichtigung des erwünschten Milchflusskurvenverlaufes bei der Selektion der Bullenväter und Bullenmütter könnte zu einer Reduzierung der somatischen Zellzahl sowie zur Verbesserung der Eutergesundheit beitragen.

Schlüsselwörter: Milchflusskurve, somatische Zellen, Eutergesundheit, Kühe

Introduction

The possibilities of curing the cow's udder from mastitis have been shrinking, and the reasons can be found in the EU decree which insists upon strict hygienic and sanitary rates as a way to healthy animals and their products. Pharmaceutical industry and veterinarian service will have to reduce drugs' use on animals (CAPUT, 1996). Furthermore udder traits and mastitis should be taken into consideration during planning of selection stratigies for improving dairy cattle perfomance, although the h^2 values for mastitis and udder traits are relatively low (NAUMANN and FAHR, 2000; IMBAYARWO-CHIKOSI et al., 2001; FAHR, 2002; BALTAY, 2002; AMIN et al.,

2002; SWALVE, 2003). Recently the most important milking parameters have been the average milk flow, the maximal milk flow, the milking duration and the milk quantity per milking. However, the technical possibilities which provide the mobile measuring LactoCorder unit have implied the complete milk flow curve measuring as well as other parameters (GÖFT et al., 1994; NAUMANN et al., 1998; FAHR, 2002). The use of such modern measuring technical could result with a larger cow number adjusted to machine milking, and a small cow number with udder illnesses (ROTH et al., 1998; NAUMANN and FAHR, 2000; FAHR, 2002).

The first research results performed by Lacto-Corder in Germany were used to define the value of certain milk flow curve parameters. For a future selective aim were suggested cows which had a high maximal milk flow (WORSTORFF, 1993). Then, the desirable maximal milk flow extent of 3,0 to 4,5 kg/min was defined and the main milking phase duration of ≤ 6 min (GÖFT et al., 1994). Establishing the connection of the milk flow and the health udder, the maximal milk flow value of 3,5 to 4,0 kg was suggested, for the somatic cell count in milk was the least (ROTH et al., 1998). A very important role had the udder's sucking canal whose width influenced the milk flow speed, as well as the udder's health (ROGERS and SPENCER, 1991; GULYAS and IVANCSICS, 2001; FAHR, 2002; AMIN et al., 2002). Similar to above mentioned, other research showed the largest somatic cell count in cows that had a high maximal milk flow and short milking duration (MIJIĈ, 2003). Therefore, animals with a longer peak milking phase and a less descending milking phase were suggested for future selective breeding. For all that, the milk drain from all udder quarters will be well balanced, "blind milking" prevented, and the health udder at least jeopardized (NAUMANN et al., 1998).

In order to prevent the health udder increase, the research aim was to establish the possibilities of using certain milk flow curve parameters in reducing the too large somatic cell count in milk. The research results could be applied in selecting the bull's mothers and fathers in bovine selective breeding.

Material and methods

175 Holstein-Frisian cows from first to third lactation from a milk farm in East Croatia were chosen for research. Only healthy cows with a normal morphological milk gland appearance were analysed. Cows treated against mastitis, with udder inflammation, in oestrus, sick, badly hurt or cows exposed to some instantaneous condition which influenced a daily milk quote were not included into research. Before each milking, the udder quarters were washed in lukewarm water, disinfected and wiped up with a dry paper tissue.

Measuring were performed by a mobile Lacto-Corder unit, Ser no. 16842, SW-Version: 93004, (manufacturer WMB AG, CH-9436 Balgach). In 1999 the unit received an international recognition by ICAR (International Committee for Animal Recording) for quantity measuring and milk sample taking by machine milking. Lacto-Corder has a possibility of graphical recording the milk flow curve from first milk flash till the milking end. Following parameters were used:

MY – the milk yield per milking (kg),
MFR – the maximum flow rate (kg/min),
AFR – the average flow rate (kg/min),
dIFR – the duration of increasing flow rate (min),

dMFR – the duration of main flow rate (min),
dPFR – the duration of peak flow rate (min),
dDFR – the duration of decreasing flow rate (min),
QPD – the relation between the duration of decreasing flow rate (dPFR) and the duration of peak flow rate (dDFR).
The milk samples taken by Lacto-Corder were analysed in the Central State Laboratory for milk quality control in Križevci whereby the somatic cell count was established by Bentley Somacount 500. The LactoCorder allows distinguishing between main milk yield and machine stripping yield. In order to reduce the required storage capacity and to help describe the milk flow curve, a number of traits are derived from the curve based on threshold flow rates. From the beginning to the end of milking these traits are:

- Duration of increasing flow rate (dIFR): Period of time from a milk flow rate >0,5 kg/min to an incline of the milk flow curve <0,8 kg/min
- Duration of peak flow rate (tPFR): Period of time between a sustained incline of the curve <0,8 kg/min and sustained decline <0,8 kg/min.
- Duration of decreasing flow rate (tDFR): Period of time between the first sustained decline of the curve >0,8 kg/min and a sustained milk flow rate <0,2 kg/min.
- Duration of main flow rate (tMFR): The add of duration of tIFR, tPFR and tDFR.

The milking equipment was checked before every milking and coordinated with the same under pressure values (43-48 kPa), pulsation relations (1:1) and tact numbers (58-60). For each cow one measuring was performed in the period of the 50^{th} to 180^{th} lactation day, whereby the German regulations (ADR, 1987) were used. To make a normal distribution, the somatic cell count in milk was converted into logarithmic (ALI and SHOOK, 1980) by means of a formula (log2 (SCC/100.000) +3) and marked as LBSS. This value was further used in statistical procedure. All statistical data analysis were performed in statistical program SPSS 10.0 for Windows. For establishing a linear connection between variables, Pearson's correlation coefficient (PROC CORR) was used.

Results

The research results of the milk flow curve and the somatic cell count are shown in Table 1.

Table 1
Means ($\bar{x}$) and standard deviation (SD) of milk flow curves and mastitis indicator; n = 175 cows (Mittelwerte ($\bar{x}$) und Standardabweichungen (SD) der Milchflusskurve und somatischen Zellgehalt; n = 175)

Trait	***Unit***	$\bar{x}$	SD	Min	Max
MY	kg	10.47	3.4	5.00	19.00
MFR	kg/min	3.88	1.51	1.02	10.51
AFR	kg/min	2.52	0.89	0.69	5.48
dIFR	min	0.71	0.58	0.04	3.17
dMFR	min	4.15	1.49	0.61	8.63
dPFR	min	1.39	1.23	0.00	5.79
dDFR	min	2.04	0.96	0.00	5.04
QPD	-	0.25	0.43	0.01	9.49
SCC	(1000/ml)	523	757	4	2990
LSCC	-	3.92	2.19	-1.64	7.90

For table 1. and 4.: MY= milk yield, MMF= maximum flow rate, AFR= average flow rate, dIFR= duration of increasing flow rate, dMFR= duration of main flow rate, dPFR= duration of peak flow rate, dDFR= duration of decreasing flow rate, QPD= quotient between dPFR and dDFR, SCC= somatic cell count, LSCC= log-transformed somatic cell count

The milk quantity per milking on average was 10.47 kg, the average milk flow of the main milking phase was 2.52 kg/min and time of the main milking phase was 4.15 min. The milk sample analysis showed that the somatic cell count in cow's milk was on average SCC= 523.000/ml, what implies a disturbed udder's health.

Table 2
Logarithmic number of the somatic cell counts (LSCC) in milk grouped by different increasing flow rates (dIFR); n = 175 cows (Logaritmische Anzahl der somatischen Zellen in der Milch gruppiert nach verschiedene Anstiegsphasendauer; n=175)

Class	n	$\bar{x}$	SD	Min	Max
≤ 0.40	45	3.47	1.89	-0.05	7.48
0.41 – 0.80	72	4.09	2.37	-1.64	7.83
0.81 – 1.20	34	4.25	2.06	-0.83	7.65
≥ 1.20	24	4.68	2.16	-0.06	7.90

The Table 2 shows the influence of the duration of increasing flow rate on the somatic cell count in milk. Cows with the shortest phase (dIFR ≤ 0.40 min) had the least somatic cell count in milk (LSCC = 3.47). Other cows with a longer dIFR had as a rule more somatic cells in milk which grew with each next class (LSCC = 4.09; 4.25 and 4.68).
Table 3 shows the relation between the duration of decreasing flow rate (dPFR) and the duration of peak flow rate (dDFR) and the logarithmic somatic cell counts (LSCC). The results shows considerable differences between the classes.

Table 3
Relation between QPD (quotient between dPFR and dDFR) and the logarithmic somatic cell counts (LSCC); n = 175 cows (Beziehung zwischen Plateaudauer im Verhältnis zur Abstiegsdauer und der logaritmischen Anzahl der somatischen Zellen; n = 175)

Class	n	$\bar{x}$	SD	Min	Max
≤ 0.40	60	4.72	2.22	-0.84	7.90
0.41 – 0.80	39	3.83	1.92	-0.06	7.83
0.81 – 1.20	36	3.37	1.96	-0.47	7.42
≥1.20	40	3.30	2.27	-1.64	7.71

Table 4
Correlations between milk flow parameters and logarithmic somatic cell count; n = 175 cows (Korelationskoeffizient zwischen Milchflussparametern und des logarithmierten Milchzellgehaltes; n = 175 Kühen)

	MY	MFR	AFR	dIFR	dMFR	dPFR	dDFR	QPD
MFR	0,52**							
AFR	0.60**	0.88**						
dIFR	0.13	0.24*	0.11					
dMFR	0.44	-0.32**	-0.34**	0.02				
dPFR	0.29**	-0.43**	-0.24**	-0.29**	0.73**			
dDFR	0.26**	-0.10	-0.29**	-0.09	0.66**	-0.15		
QPD	0.06	-0.28**	-0.07	-0.26**	0.23**	0.71**	-0.38**	
LSCC	-0.08	0.13	0.05	0.02	-0.16*	-0.25**	0.05	-0.27**

*P<0.05; **P<0.01

Phenotype correlations (Table 4) between dIFR, and dPFR and dDFR are negative and low, while between dMFR and dPFR and dDFR positive and high. Correlations are negative between the milk flow parameters (MFR and AFR) and the duration of

certain milking phases (dMFR, dPFR and dDFR). A negative correlation was as well established between QPD and LSCC.

Discussion

According to current Regulations in Croatia (N. N. 102/2000) if the cow milk contains less than 400.000 somatic cells/ml, the milk gland is considered to be healthy, and the count above this shows a disturbed health udder. The obtained health udder results are not favourable. Some former research on bovine farms in Croatia (MIJIĆ et al., 2001; MIJIĆ et al., 2004) implied a bad health condition. However, the EU countries as well had problems with a large somatic cell count. In 1991 in Sweden it was established that 26.7 % of milk samples were mastitis (EMANUELSON and FUNKE, 1991), while in Germany 45 % of researched cows had pathogenic bacteria in at least one udder quarter (ROTH et al., 1998).

The connection between the milking characteristics and the health udder is derived from a physiological connection of the udder anatomy and infection resistance. The least somatic cell count (LSCC = 3.30) was established by the highest quotient value QPD (Table 3). That means that by a longer dPFR and a shorter dDFR the udder was at least laden and less exposed to a possible infection. Such rate certainly leads to an even milking from all quarters and a “blind” milking prevention (NAUMANN et al., 1998; NAUMANN and FAHR, 2000; FAHR, 2002).

The previous research showed that the somatic cell count in milk grows with the shortening of the milking time and increasing of the milk flow (MIJIĆ et al., 2003), what should be taken into consideration by selective animal choosing.

NAUMANN et al. (1998) found also influences between the relation of dMFR to dDFR and dDFR to LSCC. The authors suggest that the correlation could be strengthened if a milk quantity correction were performed.

Implying a modern measuring technique (Lacto-Corder) in controlling the bovine productivity would significantly improve the breeding selective success (FAHR, 2002). This preventive procedure in selection would surely have a positive shift in creating more resistant cows from mastitis (GULYAS and IVANCSICS, 2001; BALTAY, 2002; KALM, 2002; SWALVE, 2003). Further research should establish genetic parameters of milking characteristics and define desirable milk flow curve with referring to cow’s health udder.

References

ALI, A. K. A.; SHOOK, G. E.:
An optimum transformation for somatic cell concentration in milk. J. Dairy Sci., **63** (1980), 487 - 490

AMIN, A. A.; GERE, T.; KISHK, W. H.:
Genetic and environmental relationship among udder conformation traits and mastitis incidence in Holstein Frisian into two different environments. Arch. Tierz., Dummerstorf **45** (2002) 1, 129-138

ARBEITSGEMEINSCHAFT DEUTSCHER RINDERZÜCHTER (ARD):
Empfehlung 3.3 für die Durchführung von Melkbarkeitsprüfungen, ADR, Bonn, RL 3.3, Stand 4 (1987), 3.1 - 3.3.

BATAY, Z.:
Influence of time of day the milk and season on the somatic cell count under Hungarian conditions. Arch. Tierz., Dummerstorf **45** (2002) 4, 349-357

CAPUT, P.:
Govedarstvo. In: Caput, I, editor, Celeber, Zagreb, (1996), 170 - 171

EMANUELSON, U.; FUNKE, H.:

Effect of milk yield on relationship between bulk milk somatic cell count and prevalence of mastitis. J. Dairy Sci., **74** (1991), 2479 - 2483

FAHR, R. D.:
Notwendigkeit und Grenzen der Züchtung auf Milchinhaltsstoffe und Milchqualität. Arch. Tierz., Dummerstorf **45** (2002) Special Issue, 51-59

GÖFT, H.; DUDA, J.; DETHLEFSEN, A.; WORSTORFF, H.:
Untersuchungen zur züchterischen Verwendung der Melkbarkeit beim Rind unter Berücksichtigung von Milchflusskurven. Züchtungskunde, **66** (1994), 23-37

GULYAS, L.; IVANCSICS, J.:
Zusammenhänge zwischen der somatischen Zellzahl und einigen eutermorphologischen Eigenschaften. Arch. Tierz., Dummerstorf **44** (2001) 1, 15-22

IMBAYARWO-CHIKOSI, E. V.; MAKUZA, S. M.; WOLLNY, C. B. A.; BANDA, J. W.:
Genetic and phenotypic parameters for individual cow somatic cell counts in Zimbabwean Holstein Frisian cattle. Arch. Tierz., Dummerstorf **44** (2001) 2, 129-137

KALM, E.:
Development of cattle breeding strategies in Europe. Arch. Tierz., Dummerstorf **45** (2002) 1, 5-12

MIJIĆ, P.; KNEŽEVIĆ, I.; RIMAC, D.; DOMAĆINOVIĆ, M.; KRALIK, D.; BABAN, M.; BAGARIĆ, D.:
Comparation of parameters of milk with new book of regulations of fresh row milk quality. Agriculture Sci. and Prof. Rev., **7** (2001), 33 - 38

MIJIĆ, P.; KNEŽEVIĆ, I.; BABAN, M.; DOMAĆINOVIĆ, M.:
Relationship of milking rate and somatic cell count to the health of bovine udders. Milchwissenschaft, **58** (2003), 119 - 121

MIJIĆ, P.; KNEŽEVIĆ, I.; IVANKOVIĆ, A.; DOMAĆINOVIĆ, M.:
Qualitative, health and bacteriological aspects of milk at dairy farms in Croatia. Milchwissenschaft, **59** (2004), 67 - 69

NARODNE NOVINE (N. N.):
Pravilnik o kakvoći svježeg sirovog mlijeka. 102/2000 of 17. 10. 2000., Zagreb

NAUMANN, I.; FAHR, R. D.; LENGERKEN, G. v.:
Zusammenhang zwischen dem Gehalt an somatischen Zellen in der Milch und ausgewählten Parametern der Milchflußkurve bei Kühen. (English Language) Arch. Tierz., Dummerstorf **41** (1998), 237-250

NAUMANN, I.; FAHR, R. D.:
Untersuchungen zum Milchfluss aus Eutervierteln. Arch. Tierz., Dummerstorf **43** (2000), 431-440

ROGERS, G. W.; SPENCER, S.B.:
Relationships among udder and teat morphology and milking characteristics. J. Dairy Sci., **74** (1991), 4189 - 4194

ROTH, S.; REINSCH, N.; NIELAND, G.; SCHALLENBERGER, E.:
Untersuchungen über Zusammenhänge zwischen Eutergesunheit, Melkbarkeitsparametern und Milchflußkurven an einer Hochleistungsrinderherde. Züchtungskunde, **70** (1998), 242-260

SWALVE, H. H.:
Neue Ansätze in der züchterischen Bearbeitung funktionaler Merkmale. Arch. Tierz., Dummerstorf **46** (2003) Special Issue, 63-71

WORSTORFF, H.:
Milchflußkurven als Basis der Erzeugerberatung zur Qualitätssicherung. Lebensmittelindustrie und Milchwirtschaft, **45** (1993), 1328 - 1333

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