Study on Milkability Traits in Holstein Cows

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ABSTRACT : The present investigation was undertaken to study the milkability characteristics of Holstein cows. Out of 6,660 initial records 4,607 records were finally included in the analysis after deleting some records with an abnormal range of values for the traits considered. These 4,607 Holstein cows belonged to a total of 122 herds located in a province in Korea. The 'LactoCorder' instrument was used to electronically record the milkability traits at the milking parlor. A total of 19 traits were studied which were broadly classified into milk yield, milking speed, milking time and the electrical conductivity related traits. The SAS 9.1 statistical software was used to carry out analyses. The average maximum milk flow per minute was 3.21 kg/min, while the average milking speed during the main milking process (DMHG) had a mean value of 2.30 kg/min. The total milk yield was 14.14 kg, 62% of which was milked during the first three minutes of the milking. The average total milking time was 8.23 min. Among the three phases of the main milking process, the time of stable milk flow had the longest time (2.97 min) followed by the time at the decline phase (2.62 min). The average time taken to reach the plateau phase was 1.08 min, which can still be reduced further through improved managemental practices. Among milk yield traits, milk yield during the first two (MG2) and three (MG3) minutes of milking had high positive correlation with milking speed traits and negative correlations with almost all the milking time traits except time of incline in milk flow from 0.5 kg/min till the attainment of the plateau phase (tAN). Milking speed traits had negative correlations with total milking time, time at main milking process, time at plateau and with the time at decline. Since there was medium to high negative correlation between the milking speed and the time at plateau, there is a need for selection of cows which have intermediate milking speed so that it could require less milking time and also the optimum (higher and longer) plateau time. Proper pre-stimulation and avoiding over milking will help in further reducing the milking time and thus will add to the net profit of the farmer. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 3 : 309-314)***

Key Words : Milkability, Holstein Cow, Correlation, Milking Time, Milking Speed

INTRODUCTION

As the new millennium step in, milking machine becomes an integral part of dairy farm operations. Its use has reduced the labor cost in milking cows. Still there is a lot of scope to reduce this time of milking to minimize the expenditure on labor as well as to maximize the number of cows milked. Thus the concept of milkability comes in picture. The milking machine should remove milk from the udder gently, quickly and completely. This principle of good milking helps describing the essential characteristics of good 'milkability' and it varies from cow to cow. Usually milkability of a cow is measured as milking speed and milking time that can be measured either by manual scoring or with a help of an instrument specially designed for studying milkability traits. Now a days traits related to milkability holds an increasing importance in selection programs. Milkability affects farmer's economy of milk production (Sivarajasingam et al., 1984) and is one of the functional traits that affect involuntary culling. Milk flow disorders cause an economic loss because of increased labor and an increased risk of mastitis (Querengasser et al., 2002).

Studies on milkability traits show that the heritability of maximum milk flow ranges from 0.21 (Santus and Bagnato, 1998) to 0.34 (Hiemstra et al., 2002) and for the stable milk flow it was 0.14 and the correlation between these two traits was -0.20 (Santus and Bagnato, 1998). The heritability of milking duration was 0.17 and predicted transmitting abilities of individual sires ranged from -0.48 min for sires with the fasted milking daughter to 0.59 min for sires with the slowest milking daughters (Zwald et al., 2005). In a preliminary study, the QTL for milking speed was suggested to be on chromosome 29 of cattle (Hiendleder et al., 2003). Above observations suggest a possible utilization of milkability traits in a selection program (Santus and Bagnato, 1998; Bagnato et al., 2003).

There is a need to have more number of studies on milkability traits so that a possible genetics and physiological basis of these important traits can be understood. Keeping in view of all the facts, the present study was undertaken with the objectives to study the variation in various milkability parameters and to access their relationship in Holstein cows.

MATERIALS AND METHODS

The study was performed on a total of 6,660 Holstein cows from a total of 178 herds located at a local province in Korea. The 'LactoCorder' instrument was used to electronically record data related milkability characteristics of the cows at the milking parlor. The LactoCorder instrument was integrated in the lactation system by inserting these into the long milk tube of the milking

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Table 1. General performance of milkability traits of Holstein cows in Korea (N = 4607)

Traits	Description	Mean	SD	Min.	Max.
Milk yield traits (kg)					
MGG	Total milk yield	14.14	4.28	5.04	30.89
MHG	Milk yield during the main milking phase	13.73	4.27	3.82	30.50
MG2	Milk yield during first 2 min.	5.50	1.67	1.24	10.00
MG3	Milk yield during first 3 min.	8.29	2.34	1.80	15.42
MNG[(1)]	Milk yield during stripping	0.45	0.48	0.02	2.98
Milking speed traits (kg/min)					
HMF	Highest milk flow	3.28	0.88	1.29	5.98
DMHG	Average milk flow on main milking phase	2.30	0.61	1.01	4.45
HMG	Maximum milk yield per min.	3.21	0.86	1.23	5.90
Milking time traits (min)					
tMGG	Time at MGG	8.23	2.25	3.22	14.98
tS500	Time to milk flow of 0.5 kg/min	0.47	0.14	0.05	0.98
tMHG	Time of main milking phase	6.20	1.99	2.10	12.97
tAN	Time of incline in milk flow from 0.5 kg/min till the reach of the plateau phase,	0.61	0.34	0.05	1.77
ttPL	Time to reach plateau phase from the start of milking tPL	1.08	0.36	0.18	2.57
tPL	Time at plateau phase	2.97	1.59	0.14	7.93
tAB	Time at decline phase	2.62	1.30	0.09	7.00
Tmng[1]	Time at stripping	0.80	0.62	0.09	2.94
Electrical conductivity traits (mS/cm)					
ELHMF	Electrical conductivity at HMF	6.13	0.56	4.35	8.91
ELAP	Electrical conductivity during the initial time of milking	6.47	0.61	4.79	10.12
ELMAX	Maximum electrical conductivity after reaching the highest milking speed	6.45	0.62	4.57	9.64

[1] 1321 records observed.

equipment ensuring that these are installed just before the junction into the milking line.

The various traits under consideration were divided into four categories; the milk yield traits (kg), the milking speed traits (kg/min), the milking time traits (min) and the electrical conductivity of milk related traits (mS/cm). The milk yield traits include the total milk yield from start to the end of milking process (MGG), milk yield during the main milking process (MHG), milk yield during first two minutes (MG2), milk yield during first three minutes of milking (MG3) and milk yield during stripping (MNG). The milking speed traits include highest milk flow measured with in a time interval of 22.4 sec (HMF), maximum milk yield measured with in a time interval of one minute (HMG) and the average main milking process per minute (DMHG). The milking time traits include the total milking time (tMGG), the time taken from beginning till the milk flow of 0.5 kg/min reached (ts500), time of incline in milk flow from 0.5 kg/min till the reach of the plateau phase (tAN), time to reach plateau phase from the start of milking (ttPL), time at plateau phase i.e. with constant milk flow (tPL), time at decline phase (tAB), time of main milking process (tMHG) and time at stripping (tMNG). The electrical conductivity related traits include the electrical conductivity during the highest milk flow (ELHMF), electrical conductivity during the initial time of milking (ELAP) and the maximum electrical conductivity after reaching the highest milking speed (ELMAX). A normal milking flow curve is presented for better understanding of the milkability traits.

The electronic data obtained by the instrument is then transferred into the computer system. Observations having an abrupt value in any of the above traits were removed from the analysis. Observations on those herds that have less than 11 records were deleted. The final data consisted of observations on 4,607 cows belonging to a total of 122 herds. Data were analyzed by using the PROC MEANS and PROC CORR described by the SAS 9.1 statistical software.

RESULTS

The number of records, mean, standard deviation, minimum and maximum values for each traits are summarized in Table 1. The average total milk production per milking was 14.14 kg, maximum of which was withdrawn during main milking process (13.73 kg) that accounts for 97% of total milk yield. On an average, 42% of milk was withdrawn during first two min and 62% of milk was withdrawn during first three min of milking. In comparison to the present findings a higher percentage (84.1%) of milk yield during first three minutes of milking

Table 2. Correlation estimates between milk yield and milking speed traits of Holstein cows

	MGG	MG2	MG3	MHG	HMF	DMHG
MG2	0.30					
MG3	0.44	0.96				
MHG	0.99	0.29	0.43			
HMF	0.30	0.95	0.93	0.29		
DMHG	0.41	0.86	0.89	0.40	0.85	
HMG	0.32	0.95	0.94	0.32	0.99	0.87

All the values are significant with $p<0.01$.

was reported in Slovak Spotted cattle (Strapák et al.,). The proportion of MG2 or MG3 against MGG would be influenced from pre-stimulation. The maximum milk yield per minute (HMG) was 3.21 kg/min, which is in agreement to the value of 3.13 kg/min reported by (Strapák et al.,). Maroney et al. (2004) reported the maximum milking speed and the average milking speed as 4.05 kg/min and 2.92 kg/min, respectively, which are quite higher than the present findings. However, the average milking speed of 1.37 kg/min in Slovak Spotted dairy cows (Vavrišínová et al.,) was reported, which are much lower than the present findings.

The average total milking time (8.23 min) in the present study is much higher than that of 4.5 min (Zwald et al., 2005) and 6.38 min (Maroney et al., 2004). The milking time should be influenced from many sources such as animal physiological effects, vacuum pressure, management etc. From these, we can get idea that there is a lot of scope to improve this trait that may be done through proper management practices and by reducing other constituent time traits. The plateau phase milking time (2.97 min) was the major time for milking during main milking phase followed by milking time during decline phase i.e. tAB (2.62 min) and both of these also account maximally for the total milking time. Since the mean time for reaching the plateau phase (tAN) is less i.e. 0.61 min, it indicates that the cows are getting proper stimulation before milking starts and so the alveolar milk is available at the earliest for milking, reducing the total milking time.

The bimodality (sudden drop in milk flow at start of milking) was observed in 18% of cows during recording, which is higher than 2.8% as reported by Maroney et al. (2004). The bimodality in the milk curve occurs due to improper stimulation or absence of pre-stimulation of cows, thus, it takes longer time to withdraw the alveolar milk than the time at which the cistern milk is drawn out. The bimodal milk flow curves can have negative effects on further milking process i.e. with temporary overmilking and the total elimination of this bimodalities is, however, not an essential prerequisite for an optimum milk let down (Lactocorder User's manual: Lactation consulting with milk flow curves). This bimodality can be checked by proper pre-stimulation of cow and timely attachment of the teat cups. Out of total recordings only 28% of cows were stripped after milking. The average stripping yield was 0.45 kg and the time at stripping was 0.80 min. About 95% of herds were found to practice stripping. The highest and the average electrical conductivity of milk during milking are given in Table 1.

Relationships among milk yield traits

Significant correlation values for the parameters of milk yield traits (Table 2) indicate that the total milk yield (MGG) was mostly related to the milk yield during the main milking process (MHG; 0.99), while correlation with the MG2 and MG3 was medium. The MHG has medium correlation with MG2 and MG3, while a very high positive correlation (0.96) was observed between the MG2 and MG3.

Relationships between milk yield and milking speed traits

The significant correlations of the MG2 and MG3 with the three milking speed traits (HMF, DMHG and HMG) revealed very strong relationship with 0.86 to 0.95 (Table 2). Moreover the time to reach to the plateau phase was almost one minute and the plateau time was almost three minutes. This indicates that the maximum milking speed occurs during the second to fourth minute of milking and that results in higher amount of MG2 and MG3, yielding almost 60% of the total milk at the end of the third minute. Despite the higher correlation of MG2 and MG3 with the speed traits, moderate relationships of MGG with the HMF and HMG were observed. This indicates that a good part of milk was yielded with low milking speed i.e. mainly during the decline phase and this may be due to uneven emptying time for the four quarters, which again suggests some disturbance in the milkability. Milk yield during the main milking process (MHG) was having medium relationship with maximum milk yield measured with in a time interval of one minute (HMG) and milking speed on highest milk flow measured with in a time interval of 22.4 sec (HMF) and slightly higher with average main milking process per minute (DMHG).

Relationships among milking speed traits

Milking speed on highest milk flow measured with in a time interval of 22.4 sec (HMF) was having very high positive relationships with the HMG (Table 2), while the relationship between HMF and DMHG was 0.85 and between DMHG and HMG was 0.87. The present results are in agreement to the findings of Banato et al. (2003) who reported a correlation of 0.81 between the maximum milk flow and the average milk flow.

Relationships between milk yield and milk time traits

Total milk yield (MGG) and maximum milk yield

Table 3. Correlation estimates between milk yield and milking time traits of Holstein cows

	MGG	MG2	MG3	MHG
tMGG	0.48	-0.36	-0.29	0.47
tMHG	0.61	-0.43	-0.33	0.62
tS500	NS	-0.07	-0.08	NS
tAN	0.06	NS	0.08	0.06
ttPL	0.05	NS	0.04	0.05
tPL	0.49	-0.48	-0.38	0.50
tAB	0.31	-0.07	-0.06	0.32

Only significant values p<0.01 are shown, NS: non significant.

Table 4. Correlation estimates of the milking speed and milking time traits of Holstein cows

	HMF	DMHG	HMG
tMGG	-0.36	-0.38	-0.35
tMHG	-0.42	-0.43	-0.41
tS500	-0.11	-0.08	-0.10
tAN	0.17	0.09	0.16
ttPL	0.12	0.05	0.12
tPL	-0.51	-0.26	-0.49
tAB	-0.07	-0.36	-0.07

All the values are significant with p<0.01.

measured with in a time interval of one minute (HMG) were having significant relationship with almost all the milking time traits except time taken from beginning till the milk flow of 0.5 kg/min (Table 3). The medium correlation of MGG with the tMGG and tMHG suggest that the milk yield has a major influence on the length of milking. This fact has also been documented by previous workers (Mein and Reid, 1996). It can be seen that the total milk yield (MGG) and milk yield during the main milking process (MHG) have very low correlation with time of incline in milk flow from 0.5 kg/min till the reach of the plateau phase (tAN) and time to reach plateau phase from the start of milking (ttPL) and this suggests that by decreasing these time, the farmer can reduce the total milking time without significant loss in the total milk yield. The correlation between the MGG and tPL (0.49) suggests that plateau phase of milking should be maximized to get maximum milk yield in minimum milking time keeping in view of the milking speed. Similarly, the MGG and tAB have good correlation (0.31) between them and thus indicates that the tPL and tAB are the two major time traits for milking and the maximum of milk is yielded during this period. More the milking capacity of a cow the more will be the values for these two time traits. But if the milking speed is high then these time traits can be reduced. The trend is almost similar for the MHG with tPL and tAB.

The significantly negative correlation of MG2 and MG3 with the tMGG and tMHG indicates that the selection for higher MG2 and MG3 will result in reduction in the total milking time, which is important from economical point of view. A significant low negative correlation of MG2 and MG3 with ts500 was observed suggesting improvement in MG2 and MG3 may be possible by decreasing the ts500. The proper pre-stimulation of the cows can reduce ts500 and it also depends upon the cistern milk present prior to milking.

A moderately negative correlation of MG2 and MG3 with tPL suggests the antagonist relationship of the two milk yield traits with the time at plateau. This may be because of higher milk flow during second and third minutes of milking which causes early depletion of milk in one or more of the four quarters of udder resulting in short tPL. Generally, hind quarters yield more milk than the front quarters (Rothenanger et al., 1995; Wellnitz et al., 1999). This uneven emptying of the four quarters can be avoided by selecting the animals that have optimum milking speed and by adjusting the milk flow for all the four quarters separately. The result also suggests that if the tPL is too lengthy then there must be slow milk speed through out the milking giving less milk during second or third minute and thus increases the time of total milking. Such type of milk profile animals must be culled as they hamper the timely milking of other cows thus creates an additional labor cost to the farmers.

The correlation of the tAB with the MG2 and MG3 was -0.07 and -0.06, respectively. This negative relationship may be due to the fact that the tAB depends on the amount of milk left for milking after the plateau phase and higher the MG2 and MG3 the lower will be the tAB.

Relationships between milk speed and milking time

All the three milking speed traits (HMF, DMHG and HMG) have medium negative correlations with tMGG and tMHG indicating that an increase in milking speed will decrease the milking time (Table 4). This suggest that to decrease the labor time the milking speed should be high, but it should also be noted that the higher the milking speed the higher is the chances to get damage to the udder or risk of mastitis (Boettcher et al., 1998). So the best way to minimize the mastitis risk and to have milking in less time is the selection of cows having moderate milking speed removing the cows with too higher and too lower milking speed.

The negative relationship between milking speed traits (HMF, DMHG and HMG) with time taken from beginning till the milk flow of 0.5 kg/min reached (ts500) suggests that milking speed can be improved by decreasing the time to reach the speed of 0.5 kg/min and that may be done by improving the management practices such as proper pre-stimulation of the cows. The results show a positive correlation between HMF and tAN and HMG and tAN, which suggest that an increase in the time of inclination have an effect on the maximum milking speed. Too high a maximum milking speed is also not favorable to the farmers as it may cause health disorders to cow and also the sudden

Table 5. Correlation estimates among milking time traits of Holstein cows

	tMGG	tMHG	tS500	tAN	ttPL
tMHG	0.80				
tS500	0.13	0.07			
tAN	-0.04	-0.04	-0.09		
ttPL	NS	NS	0.31	0.92	
tPL	0.58	0.74	0.08	-0.24	-0.20
tAB	0.52	0.63	NS	NS	NS

Only significant values p<0.01 are shown, NS: non significant.

rise in speed will cause the uneven plateau and uneven emptying of the four quarters of the udder. Time at plateau phase (tPL) is negatively related with the milking speed traits with a correlation of -0.51 with HMF, -0.49 with HMG and -0.26 with DMHG. In agreement to the present findings a correlation of -0.20 between the average milking speed (DMHG) and the time at plateau (tPL) was reported (Bagnato et al., 2003). Thus based on all these observations it can be concluded that the too high speed will hamper the constant milk flow (time at plateau reduces) that may results in uneven emptying of the four quarters (Seeman, 1997; Svennersten, 2004) and may lead to overmilking (Rasmussen, 2004) and thus the possible damage to the quarter that has milked out early.

The results show low negative correlations of the HMF and HMG with the time at decline (Table 4), while the average milking speed was having a correlation of -0.36 with time at decline phase (tAB). This again favors the high milking speed to reduce the tAB and the total milking time (TMGG) and thus gain in profit.

Relationships among milking time

The total milking time (tMGG) was closely related (0.80) to the time for main milking phase (tMHG) (Table 5). This relationship should be closer to reduce the total time without significantly affecting the total milk. This can be achieved by proper management practices reducing the over-milking time. The tMGG was positively related with ts500 (0.13), tPL (0.58) and tAB (0.52). Also the tMHG was closely related with the tPL (0.74) and tAB (0.63) suggesting that these two traits (tPL and tAB) constitutes the major part of total milking time. There was very low negative correlation of tMGG and tMHG with the tAN. This seems to be a contradictory situation where tAN is a part of tMGG or tMHG and have negative correlation with them. Moreover the correlation of the tAN with tPL and tAB was negative, thus supporting the above interpretation. If this is the case then farmers will have to see that the tAN should be optimum to ultimately reduce the total milking time. However a study on physiological mechanism is required to confirm this.

Electrical conductivity

The milk yield traits such as MGG, MG2, MG3 and MHG have low positive correlation with electrical conductivity traits ELHMF, ELAP and ELMAX (Table 6). Nielen et al. (1993) reported a decline of 0.88 kg/d in milk production with a rise of 1 mS of the mean electrical conductivity. The authors also suggested that the electrical conductivity and SCC have an additive effect on the loss in daily milk production. The electrical conductivity of milk is utilized as an indicator of somatic cell count in cows over a decade, and it may be considered as a potential trait in a breeding program where selection for improved udder health is included (Norberg et al., 2004). The milking speed traits have low positive correlation with ELHMF, ELAP and ELST (Table 6), while all the three electrical conductivity traits were very closely related with each other.

DISCUSSION

The milkability of a cow is now gaining importance among the dairy owners. Milkability includes those traits that are related to the milking speed, milking time and the total milk yield. The main concern of a farmer to study these traits is to minimize the total milking time of a cow and so of his herd without adversely affecting the total milk production. This may be achieved if the milking speed of the herd is high. In the present study, the total milk yield is having medium relationship with the total and the main milking time, which suggests that the reduction in milking time may adversely affect the total yield. But the moderately negative correlation of MG2 and MG3 with the total and main milking time suggests the reduction in milking time with the increase in the milk yield during second and third minute of milking. So the selection of animals for higher MG2 and MG3 may improve the milkability of the herd. These periods also constituted the major part of time at plateau and the results indicated a negative correlation of MG2 and MG3 with the time at plateau. But this negative correlation may be due to those records that have very high speed at start of plateau which results in higher MG2 and MG3 yields and this causes early empting of one or more quarters of the udder resulting in

Table 6. Correlation estimates between the milk yield and electrical conductivity traits of Holstein cows

	MGG	MG2	MG3	MHG	HMF	DMHG	HMG	ELHMF	ELAP
ELHMF	0.13	0.10	0.09	0.13	0.08	0.05	0.08	1.00	0.78
ELAP	0.05	0.06	0.07	0.05	0.11	NS	0.10	0.78	1.00
ELMAX	0.05	0.04	NS	0.05	NS	NS	NS	0.86	0.75

Only significant values p<0.01 are shown, NS: non significant.

shorter plateau time. This fact was also confirmed by our results that show negative correlations between the milking speed and the time at plateau. Thus the milking speed is the important trait for the milkability. The higher the milking speed the less will be the milking time, and this is confirmed by the present results with negative correlation of milking speed with the total or main milking time.

The results show that the time at plateau (tPL) and time at decline phase (tAB) has also a major contribution to the total or main milking time and also has good milk yield during this period. This trait has negative correlation with the milking speed and the MG2 and MG3 suggesting increase in the later traits may reduce the tAB.

Thus from the results of present study it may be suggested that a cow with good milkability is one that have tendency to have optimum speed and dry out its maximum milk during the plateau phase within four minutes of milking. A good management practice is also required for achieving good milkability of herd which includes avoiding the bimodality in the milking curve by timely pre-stimulation of the cow before milking, adjusting the flow of all the four quarters to allow their simultaneous emptying thus checking the overmilking of the udder and avoiding too high milking speed to reduce the risk of mastitis.

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