Effect of calf rearing management on milk yield and udder health of crossbred dairy cattle in Thailand

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The Thai dairy industry meets only about 30-40 % of the domestic milk demand. Milk production in Thailand is based on crossbred dairy cattle. Machine milking of cows and bucket rearing of calves is propageted. Yield per cow amounts to 8-10 kg/day. The mastitis incidence is high (56 %) under smallholder management and is a more serious problem in herds with machine milking than with hand milking.

This paper reports results of a study conducted to evaluate the effect of calf rearing management and milking method on milk production and udder health of cows.

Forty crossbred (75-87.5% HF) dairy cows were included in a 2 x 2 factorial experiment composed of hand milking (HM) or machine milking (MM), and artificial rearing (bucket feeding, AR) or restricted suckling (RS). Calf suckling and milk feeding was done until 84 days postpartum. Milking was continued until the end of lactation. MM cows had a significantly ($p<0.05$) higher daily saleable milk production (SMP) (7.49 vs. 6.97 kg/day), daily total milk production (TMP) (8.60 vs. 7.96 kg/day) and total lactation milk yield (TLMY) (2297.72 vs. 2137.41 kg) than HM cows. The RS cows produced significantly ($P<0.001$) more TLMY (2455.46 vs. 1979.68 kg), annual total milk yield (ATMY) (2277.23 vs. 1970.73 kg), lactation saleable milk yield (LSMY) (2165.90 vs. 1724.64 kg), annual saleable milk yield (ASMY) (2035.21 vs. 1721.17 kg) and daily saleable milk production (SMP) (7.98 vs. 6.47 kg/day) than the AR cows. The MM cows showed a significantly ($p<0.001$) higher somatic cell score (SCS) than their HM herdmates throughout the study period. The AR cows exhibited a significantly ($p<0.001$) higher SCS than RS cows.

Keywords: restricted suckling, artificial rearing, daily total milk production, daily saleable milk production, total lactation milk yield, annual total milk yield, lactation saleable milk production, somatic cell score, crossbred, Holstein Friesian

Introduction

The Thai government since 1977 has followed a policy to attain self-sufficiency in milk production and to increase milk consumption. Between 1991 and 1996 dairy cattle numbers have increased from 102,717 heads to 167,181 heads and milk production from 164,340 t to 380,101 tons. However, total production of raw milk still meets only about 30-40 % of the domestic consumption demand (Chantalakhana, 1995).

Machine milking and bucket rearing of calves is propagated in dairy enterprises and small holder dairies. The majority of Thai dairy cattle are crossbreds between Local and Holstein Friesian. Average milk yield of a crossbred cow is 8-10 kg/head/day or 2700-3000 kg/lactation with a

lactation period of 250-300 days. Furthermore, one of the serious problems is the high rate of mastitis in dairy herds (Polpak, 1994; Vinther, 1974). This does affect milk yield as well as the manufacturing properties of milk (Firat, 1993). Polpak (1994) reported 58.6 % of mastitis cases in dairy cattle under smallholder management. Though the economic loss was not reported, most of the mastitis cows were culled from herds.

This paper reports results of an experiment comparing the effect of hand or machine milking and restricted suckling or bucket feeding of calves on milk performance and udder health.

Materials and methods

The experiment was conducted from February 1997 to October 1998 at Ubon Ratchathani University, Ubon Ratchathani province, Thailand. Forty Holstein Friesian crossbred cows were allotted to the treatments at the time of calving. The experiment started at day 4 postpartum and ended when the average daily yield of a cow during a full week did not exceed 2 kg. The cows were arranged into a 2x2 factorial experiment with two calf rearing treatments (artificial rearing/bucket feeding twice daily between day 4-84 postpartum (AR) and restricted suckling (RS) for 15 minutes after each milking time, twice daily between day 4-84 postpartum) and with hand milking (HM) and machine milking (MM) twice daily.

Lactating cows were kept day and night in-house from calving to day 84 post calving, and from day 85 until the end of lactation on pasture during daytime and in-house during night time. The shed had a concrete floor and was well ventilated. The cows grazed a grass-legume pasture composed of *Brachiaria ruziziensis* (Ruzi) grass and *Stylosanthes hamata* legume during 6.30-15.30 hr. and they received a yield dependent concentrate supplementation according to NRC (1989) recommendations. The cows received ad libitum access to water and a mineral block both in the shed and on pasture.

During the first three days postpartum the calves and were allowed to suckle freely. From the fourth day of lactation milking was done at 05.30 and 16.00, respectively.

The udder of all experimental cows were washed with 0.5 % Iodophor solution and dried with a cotton cloth before milking and teats were dipped after milking with 0.5 % Iodophor. Each animal had a separate cloth. In the case of RS, the udder was washed with clean water and dried before suckling. Post-suckling, the teats were dipped with 0.5 % Iodophor again.

Milk yield was recorded daily. The amount of milk consumed by suckled calves was evaluated by weighing the calves before and immediately after suckling. The change in mass at each suckling was assumed to be the quantity of milk consumed by the calf. Milk yield was computed to the following yield traits:

SMP = milked-out volume minus amount of milk bucket fed to calf

TMP = milked-out volume plus amount milk suckled by calf

TLMY = Total milked-out volume from the 4^{th} day until the end of lactation plus total amount of suckled milk during day 4-84 post partum

ATMY = (TLMY x 365) / calving interval

LSMY = Total milked-out volume from the 4^{th} day until the end of lactation minus total amount of milk bucket fed to calf during day 4-84 post partum

ASMY = (LSMY x 365) / calving interval

TLMY/CI = TLMY / day of calving interval

The somatic cell count (SCC) was done on the morning foremilk from each quarter of the cows every two weeks, starting the second week until week 36 of lactation. The number of somatic cells in milk samples were determined within 48 hours by the Prescott and Breed microscopic cell count method as described by AOAC (1984). The number of counted cells were transformed to a somatic cell score (SCS) as described by Goodwin and Spelman (1994). The transformation data were geometric mean of the log-transformed SCC and were calculated using the following equation :

$$SCS = 3 + \log_2 (SCC/100,000)$$

The SAS procedure for General Linear Models (GLM) of the Statistical Analysis System Release 6.12 (SAS, 1998) was used for the analysis of variance. The following linear models were used for the different traits:

Model 1 : Daily SMP, daily TMP, TLMY, ALMY, LSMY, ASMY, TLMY/CI and lactation length.

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

Model 2 : Somatic cell score (SCS).

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \chi_k + \delta_l + \alpha\chi_{ik} + \beta\chi_{jk} + e_{ijkl}$$

Where

Y_{ijkl} = dependent variable
μ = mean
α = effect of calf rearing management
β = effect of milking method
χ = effect of week of lactation
δ = effect of quarter position
e_{ijkl} = residual error

Results

Daily milk production

-Saleable milk production (SMP)

A major effect on daily SMP was caused by the calf rearing management with a highly significant ($p<0.01$ or $p<0.001$) larger SMP in restrictedly suckled cows compared to non suckled cows throughout the study period (Table 1). Of special interest is the additional SMP of 3.08 kg/day during the first 3 months of lactation of cows under the RS management. These results indicate that RS cows had a higher daily SMP than AR cows by 46.50, 14.97, 11.83, 29.09 and 23.18 % during the periods 4-84, 85-168, 85-252, 4-168 and 4-252 days of lactation, respectively (Table 1).

Table 1 Least squares means of daily saleable milk production (SMP) of the cows

Main effects	n	Average daily SMP (kg/day)				
		Day 4-84	Day 85-168	Day 85-252	Day 4-168	Day 4-252
Calf rearing		***	**	**	***	***
Artificial	20	6.75±0.24	7.55±0.25	6.34±0.18	7.16±0.22	6.47±0.18
Restricted suckling	20	9.83+0.24	8.68+0.25	7.09+0.18	9.24+0.22	7.98+0.18
Milking method		**	ns	ns	*	*
Hand	20	7.76±0.24	7.99±0.25	6.58±0.18	7.88±0.22	6.97±0.18
Machine	20	8.81±0.24	8.24±0.25	6.85±0.18	8.52±0.22	7.49±0.18
Mean±sem		8.29±0.17	8.20±0.18	6.79±0.13	8.19±0.16	7.23±0.13

ns = non significant, * = p<0.05 ** = p<0.01 and *** = p<0.001

The milking method influenced daily SMP during day 4-84 (p<0.01), 4-168 (p<0.05) and day 4-252 (p<0.05) of lactation, but not in the periods of day 85-168 and day 85-252 of lactation (Table 1). The largest influence was observed in the first 16 weeks of lactation, during which lactation yield increased consistently. Cows of the machine-milking group had a significantly higher daily SMP than those being hand-milked.

-Total daily milk production (daily TMP)

Machine-milking yielded a significantly (p<0.01 or p<0.001) higher TMP in the periods of day 4-84, 4-168 and 4-252 of lactation (higher by 8.04-12.14 %), but not in the period of day 85-168. The largest difference to the hand-milking group was observed during the first 3 lactation months (+12.14 %).

The calf rearing system and milking method had significant effects on daily TMP (Table 2). Cows of the suckling group had a significantly (p<0.01 or p<0.001) better daily TMP than the non-suckled group throughout the study period. It was found that the daily TMP of RS cows exceeded the AR cows by 35.98, 13.30, 11.09, 25.72 and 21.69 %, respectively, during the periods of day 4-84, 85-168, 85-252, 4-168 and 4-252 of lactation (Table 2).

Table 2 Least squares means of daily total milk production (TMP) of the cows

Main effects	n	Average daily TMP (kg/day)				
		Day 4-84	Day 85-168	Day 85-252	Day 4-168	Day 4-252
Calf rearing		***	**	**	***	***
Artificial	20	9.70±0.25	7.67±0.24	6.40±0.18	8.67±0.22	7.47±0.18
Restricted suckling	20	13.19+0.25	8.69+0.24	7.11+0.18	10.90+0.22	9.09+0.18
Milking method		***	ns	ns	*	*
Hand	20	10.79±0.25	8.03±0.24	6.60±0.18	9.39±0.22	7.96±0.18
Machine	20	12.10+0.25	8.33+0.24	6.91+0.18	10.18+0.22	8.60+0.18
Mean±sem		11.45±0.18	8.28±0.17	6.84±0.13	9.79±0.16	8.28±0.13

ns = non significant, * = p<0.05, ** = p<0.01 and *** = p<0.001

Overall lactation performance

The least squares means for treatments are compiled in Table 3. Both treatments significantly affected the TLMY yield, witch had an overall mean of 2235.45 kg. The RS cows had a 24.03 %

higher TLMY than their AR herdmates. Machine-milking improved yield by 7.58 % as compared to hand-milking.

Restricted suckling caused a highly significant improved TLMY and ATMT, with a difference of 24.03 % and 15.55 % resp. (Table 3).

Restricted suckling of cows also led to a significant higher LSMY ($p<0.001$) and ASMY ($p<0.05$) (Table 3) with a 25.59 % and 18.25 % advantage over cows without suckling. It is also noteworthy that RS cows exhibited a higher TLMY per day of calving interval than non suckled cows..

The milking method treatment failed to significantly affect the ATMY, although machine-milking again led to higher yields.

In this study, the earliest drying off date was at day 252 of lactation and the latest drying-off date occurred at day 377 of lactation. It was found that 2.5 % of cows were dried off at the 252nd day, 25.0 % during day 253-280, 50.0 % during day 281-308 and 22.5 % during period 309-377 days of lactation.

Results in Table 3 indicate that cows exposed to restricted suckling during day 4-84 of lactation exhibited a highly significantly ($p<0.001$) longer lactation period (307.34 days) than non suckled cows (283.80 days). The milking method had no influence on lactation lengths.

Table 3 Least squares means of total lactation milk yield (TLMY), annual total milk yield (ATMY), lactation saleable milk yield (LSMY), annual saleable milk yield (ASMY), total lactation milk yield/day of calving interval (TLMY/CI) and lactation length of the cows

Main effects	n	TLMY (kg)	ATMY (kg)	LSMY(kg)
Calf rearing		***	***	***
Artificial	20	1979.68±47.02	1970.73±61.97	1724.64±79.29
Restricted suckling	20	2455.46+46.92	2277.23+61.85	2165.90+80.93
Milking method		*	ns	ns
Hand	20	2137.41±46.92	2040.27±61.85	1909.77±80.93
Machine	20	2297.72+47.02	2207.69+61.98	1980.77+79.29
Mean±sem		2235.45±33.54	2160.35±44.21	1942.20±57.14

Main effects	n	ASMY (kg)	TLMY/CI (kg/day)	Lactation length (day)
Calf rearing		*	***	***
Artificial	20	1721.17±90.89	5.40±0.17	283.80±4.53
Restricted suckling	20	2035.21+92.77	6.24+0.17	307.34+4.52
Milking method		ns	ns	ns
Hand	20	1833.34±92.77	5.58±0.17	294.99±4.52
Machine	20	1923.05+90.89	6.05+0.17	296.15+4.52
Mean±sem		1878.94±65.51	5.92±0.12	294.45±3.23

ns = non significant, * = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$

Udder health

Somatic cell count was measured for every individual udder quarter of all 40 cows every week from the second week postpartum until the 36th week of lactation. It was found that the total incidence of

mastitis cases (cows) and quarters were 17.5 and 6.25 %, respectively. Left quarters had a higher rate of clinical mastitis than the right quarters (9 vs. 1 udder). A mastitis case has registered if the SCC is higher than 400,000 cells/ml.

It was found that cows exposed to AR management exhibited a significantly ($p<0.001$) higher SCS than suckled cows (+3.48 %) (Table 4) and cows exposed to machine-milking showed a higher SCS than hand-milked herdmates.

Table 4 Least squares means of the SCS during weeks 2-36 of lactation

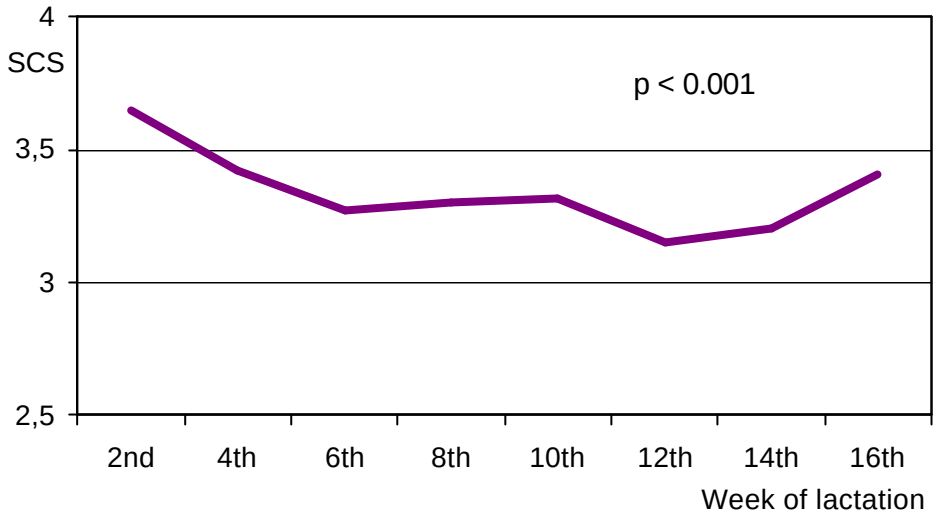
Main effects	n	SCS
		***
Calf rearing		
Artificial	1440	3.57±0.02
Restricted suckling	1440	3.45±0.02
		***
Milking method		
Hand	1440	3.33±0.02
Machine	1440	3.69±0.02
		***
Quarter		
Left front	720	3.60±0.02[a]
Right front	720	3.56±0.02[a]
Left rear	720	3.55±0.02[a]
Right rear	720	3.33±0.02[b]

*** = $p<0.001$

[a,b,c,...,j] : Means with different superscripts within column of the same effect differ significantly

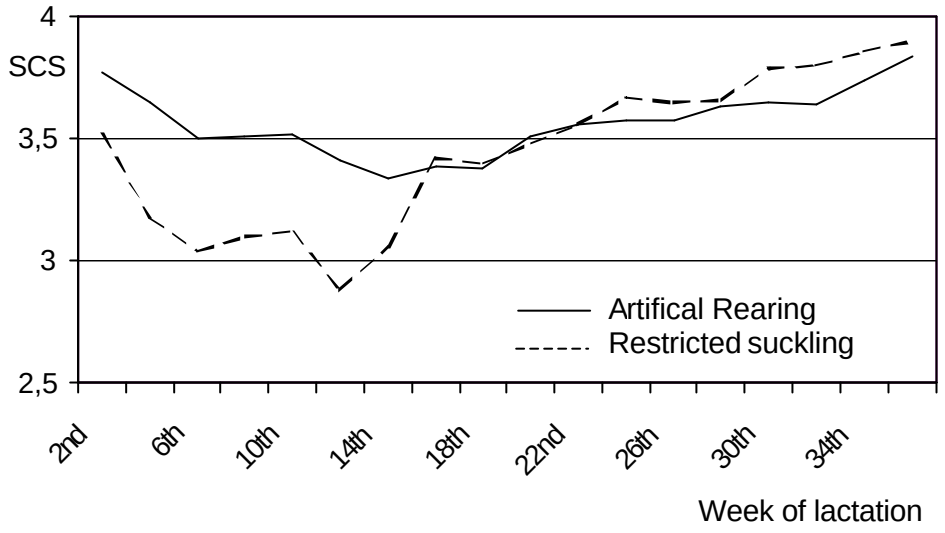
As expected, quarter position had a highly significant ($p<0.001$) influence on SCS of the cows. Week of lactation had also significantly ($p<0.001$) affected SCS during weeks 2-36 of lactation. The SCS pattern over the lactation period showed a higher SCS during the first lactation period (week 2-4) and during the third lactation period (week16-36), which can be associated to a dilution effect (Figure 1).

Figure 1. Least squares means of the SCS during weeks 2-36 of lactation



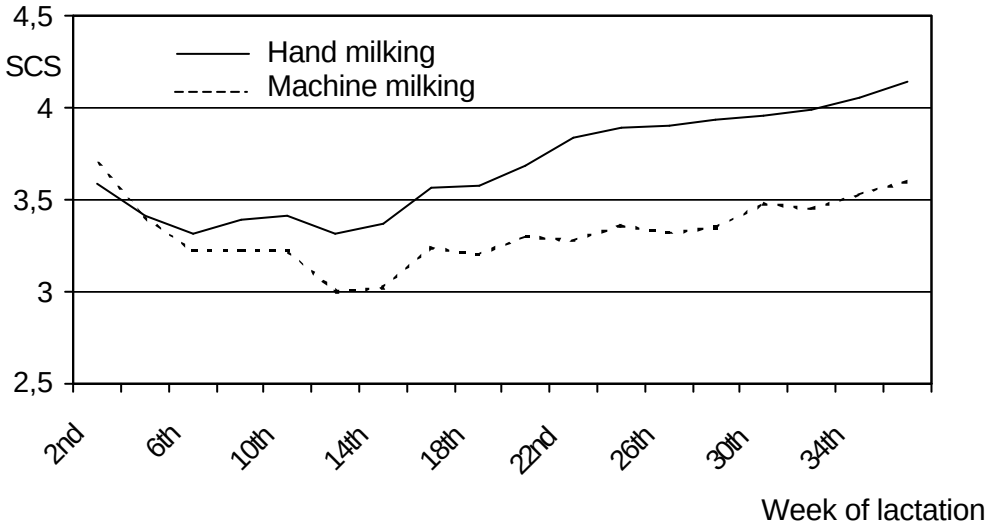
Restricted suckling leads to a highly significant (P < 0.001) lower SCS (Table 5). From 4–84 days of lactation cows allotted to the RS treatment were allowed to suckle their calves for 15 minutes twice daily after each milking time, while the AR cows did not nurse their calves which caused a 7-18 % lower SCS in the former group. After weaning the SCS patterns in both of the AR and RS cows were sim0ilar and followed the normal pattern of a slightly increased SCS with lowering milk yield (Figure2).

Figure 2. Least squares means of the SCS during weeks 2-36 of lactation ($p < 0.001$)



The milking method caused a highly significant difference in SCS over the lactation period (Fig. 3). During weeks 2-10 of lactation both hand-milked and machine-milked cows exhibited the same pattern of SCS alteration, and the results clearly showed a different SCS pattern between both milking methods starting from week 12 until week 36 of lactation causing a 10-18 % higher SCS in machine milked cows over their hand milked herd mates.

Figure 3. Least squares means of the SCS during weeks 2-36 of lactation ($p < 0.001$)



Discussion

Effect of calf rearing management and milking method on milk production

Restricted suckling of cows caused an increased SMP and TMP, and also improved annual milk yield and milk yield per day of Calving Intervall in comparison to cows without suckling. These results in agreement with reports by Alvarez et al. (1980a), Little et al. (1991), and Ugarte and Preston (1975) and confirm the higher utilization of cows' milk potential when milking is combined

with suckling. Restricted suckling utilizes residual milk, which is not obtained in cows without restricted calf suckling. The increased milk yield over a long period must result from an increased rate of galactopoiesis. Suckling stimulates releasing of oxytocin, which affects the milk ejection (Wagner and Oxenreider, 1972). Suckling also stimulates the release of prolactin, adrenocorticotropin and somatotropin which is thought to maintain galactopoiesis in many species (Tucker, 1985).

Dodd and Phipps (1985) stressed the role of the strong milk ejection reflex in enabling the milker to obtain the maximum possible amount of milk and to leave only a minimum amount of residual milk. Milk ejection is induced by enhanced release of oxytocin from the pituitary gland in response to tactile stimulation such as suckling (Gorewit and Gassmann, 1985). Without pre-milking stimulation, milk flow is reduced or totally interrupted after removal of the cisternal milk until oxytocin-induced milk ejection occurs (Bruckmaier and Blum, 1996). Myoepithelial cells are sensitive to mechanical stimulation and the tap reflex, induced by the butting calf , may augment the action of oxytocin on these cells (Findlay and Grosvenor, 1967). Milk ejection probably is most efficient when mechanical stimuli and oxytocin combine to contact the myoepithelial cells (Goodman and Grosvenor, 1983).

The higher milk yield of machine-milked cows over their hand-milked herdmates may be explained by the longer duration of the hand-milking process and the effect of disturbances caused by the less uniform hand-milking process, which can cause a negative effect on milk let down. Because milk ejection is transitory, Barrett and Larkin (1974) suggested the maximum milk yield is obtained when milking is quick so as to fall within a short period of some hormonal effects. In the present study, actually we noticed that it took approximate between 5-8 minutes per each cow for one hand-milking and 3 to 6 minutes for machine-milking, respectively. The shorter milking time when using the machine-milking method, may explain the yield advantage of machine-milking over hand-milking.

Shorter lactation lengths of cows with artificial rearing of calves as compared to cows with restricted suckling were also found in other reports (Alvarez et al., 1980a; Ugarte, 1991). Ugarte and Preston (1972), and Ugarte (1991) showed that the presence of a suckling stimulus over a longer period (six months) prolonged lactation length. The longer lactation length may relate to the higher persistency of milk production in cows managed under RS system over the AR system.

Effect of calf rearing management and milking method on udder health

The overall pattern of SCS during lactation is consistent with reports by Funke and Schlote (1999) and Emanuelson and Philipsson (1984).

Cows exposed to AR management exhibited a highly significant ($p<0.001$) higher SCS than suckled cows. During the period day 4-84 of lactation there was no case of mastitis in the RS group, while 3 cows of the AR treatment group exhibited a high SCS during. Thereafter, mastitis cases were found in both groups of calf rearing treatment groups with five in the AR but only two cases in the RS group, respectively. The lower SSC in AR cows may have been caused by the better evacuating of the udder through suckling which caused also a reduction in the number of pathogens and amount of the residual milk. These results are in agreement with Alvarez et al. (1980b), Mejia et al. (1998), Sahn et al. (1997), Ugarte (1991), and Ugarte and Preston (1975) who reported no incidence of mastitis in crossbred dairy cow during the calf suckling period.

The larger SCS of the machine-milked cows as compared to the hand-milking group in this study could be caused by the fact that the machine-milking process offers multiple opportunities for microorganism to infect the udder. During milking, vacuum fluctuations in the claw head leads to

milk moving between teat cups. If the cow being milked has one or more infected quarters, this process transfers pathogenic microorganism to the surface of other teats. After a cow has been milked, the inner liner surface of the milking machine could carry microorganism originating from the infected quarters which can be transferred to the next animal if the teat cups are not disinfected in between milking of cows.

Machine-milking can influence the exposure of the teat orifice and duct to pathogenic organisms. Machine-milking may lead to hyperkeratosis of the teat orifice, and may also lead to haemorrhagic blisters at the teat end, to teat chapping and lesion. Such skin abnormalities are readily colonized by pathogenic microbes, and may lead to intramammary infections. Hamann and Stanitzke (1990) expressed that machine-milking caused a significant increase in thickness of the teats, which does not occur with hand-milking and calf suckling. Thirty minutes after milk withdrawal by suckling or hand-milking the teats returned to their pre-milking levels, while the mean recovery time for machine milked teats was 1-2 hours (Hamann, 1989).

Machine-milking may also cause trauma to the teat rendering it more susceptible to colonization and infection. Trauma to the mucous membranes lining the teats sinus may provide an environment favoring bacteria colonization or multiplication. Local pain may lead to neurohormonal responses which suppress immune function and increase the likelihood of disease. The effect of continued use of machine-milking on the cow's udder and teats cannot be underestimated. The damaging effect or milking machine on the cow's udder and teat sometimes does not show up for several months or even years (Noorlander, 1960).

The quarter position significantly ($p<0.001$) influenced the SCS of the cows. It was found that the quarter in the right rear position of the udder had the lowest score of 3.33, whereas the others had values ranging from 3.55 to 3.60. This may be caused by "blind milking effect". It was observed in this study that the working position of the milkers during milking process in both hand-milking and machine-milking were on the right side of the cows. At this position, the right quarters were managed more carefully as compared to the left side quarters which are out of sight.

Week of lactation (stage of lactation) also significantly ($p<0.001$) affected the SCS during weeks 2-36 of lactation. The alteration pattern of SCS was similar to the pattern of change of milk components, high SCS were found during the first weeks of lactation and again during late lactation (week16-36). The shape of this curve indicated a possible effect of dilution, and can be describe as the inverted milk production curve (Emanuelson and Persson, 1984; Kennedy et al., 1982).

Conclusion and recommendation

The restricted calf suckling management in combination with milking has never been practised in any milk production system in Thailand. The results of this study indicate that strategies of dairy production with restricted suckling of crossbred Holstein Friesian dairy cows can improve milk production performance of saleable and increased lactation milk yield even though suckling ended on day 84 of lactation.

The restricted suckling system significantly improved SCS, and sustained the udder health during suckling period and this also had a carry over effect a few weeks after the end of calf suckling period.

The results obtained under Experiment-Station conditions already indicate the potential problem of machine milking, which under practical condition in small farms could cause major udder health problem with highly significant financial consequences in terms of the productive live of a cow and treatment cost.

Restricted suckling is therefore a more appropriate and sustainable system for managing cows than the removal and artificial rearing of calves and, thus, can be highly recommended for smallholder farmers. The introduction of restricted suckling for crossbred dairy cows may require a training of smallholders as they are not familiar with this production system.
Machine milking has a clear advantage in cows with higher milk yields but it has a significant negative effect on udder health. Sustainable machine milking therefore requires extreme care and many smallholders in Thailand may benefit from staying with hand milking due to a lower cost and disease risk.

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