CHAPTER IV

RESULTS

Study A

General characteristic of dairy farms

The sample size of dairy farms in this study is 104 farms. The descriptive statistics of dairy farms in this study are presented in Table 3. The median number of milking cows is 8 (range = 1 – 18) and the median milk production per herd is 92.5 kg of milk per day(range = 15 – 240). The most common type of milking system is bucket type machine milking (85.58%). The median of SPC was 1,584,962 colony forming unit/ml (cfu/ml) ($\log_{10}$ median = 6.20). The MCCs were divided by the bacterial counts into 2 groups; group1: MCCs which had high bacterial count in raw milk (average of $\log_{10}$SPC > 6.20) and group2: MCCs which had low bacterial count in raw milk (average of $\log_{10}$SPC $\leq$ 6.20). The descriptive statistics for continuous farm-level variables are in Table 4, and the descriptive statistics for categorized farm-level variables are in Table 5.

Table 3 Descriptive statistics of sampled dairy farms

Farm characteristic	Minimum	Maximum	Median
Total milking cows	1	18	8
Milk production per herd (kg/day)	15	240	92.5

Table 4 Descriptive statistics of continuous farm-level variables studied for their association with high or low bacterial counts at the milk collecting center level

Variable	High bacterial counts				Low bacterial counts				OR	*p*-value
	N	First quartile	Median	Third quartile	N	First quartile	Median	Third quartile		
Duration of dairy farming (years)	54	8	10.5	15	49	4	8	12	0.888	0.045
Milk production (kg/day)	54	70	110	160	50	32	75	110	0.984	0.015
Milk price (baht/kg)	54	10.75	10.80	10.85	50	10.80	11.00	11.00	0.535	0.722
Average monthly income (baht/month)	53	10,000	15,000	20,000	47	5,000	13,000	20,000	1.000	0.081
Milking duration (min)	54	60	90	120	50	60	75	90	0.996	0.679
Milk transportation duration (min)	54	5	10	20	50	10	30	30	<0.001	0.015
Milking machine age (years)	53	4	6	7	35	1.5	5	7	0.778	0.066
Liner age (months)	53	2	4	7	35	3	6	6	1.027	0.778
Total milking cows	54	6	9	12	50	3	7	9	0.770	0.011
Milking cows with 0 mastitis	54	6	8	11	50	3	6	7	0.735	0.009
Milking cows with 1 mastitis	54	0	0	1	50	0	0	1	0.566	0.105
Milking cows with >1 mastitis	54	0	0	0	50	0	0	1	0.848	0.554

Table 5 Descriptive statistics for categorized farm-level variables studied for their association with the bacterial counts in raw milk at the milk collecting center level

Categorized variables	Categories	High SPC		Low SPC		OR	*p*-value
		N	%	N	%		
Training program	No	6	11.11	5	10	0.667	0.663
	Yes	48	88.89	45	90		
Typing barns	No	41	75.93	29	58	1.688	0.414
	Yes	13	24.07	21	42		
Barn ventilation	Poor	0	0	1	2	0.152	0.094
	Fair	11	20.37	13	26		
	Good	43	79.63	36	72		
Floor condition	Wet	19	35.19	22	44	0.645	0.501
	Dry	35	64.81	28	56		
Barn cleanliness	Poor	13	24.07	19	38	0.521	0.402
	Good	41	75.93	31	62		
Manure management	Poor	2	3.70	7	14	<0.001	0.969
	Good	52	96.30	43	86		
Cow cleanliness	Poor	3	5.55	1	2	1.266	0.667
	Fair	20	37.04	14	28		
	Good	31	57.41	35	70		
Cow washing	No	1	1.85	9	18	<0.001	0.972
	Yes	53	98.15	41	82		
Dry the cow's body	<15 min	8	14.81	11	22	0.857	0.856
	>15 min	46	85.19	39	78		
Udder wash by disinfectant	No	41	75.93	31	62	1.429	0.577
	Yes	13	24.07	19	38		

Table 5 (continued)

Categorized variables	Categories	High SPC		Low SPC		OR	*p*-value
		N	%	N	%		
Udder dry before attachment	No	37	68.52	17	34	3.667	0.059
	Yes	17	31.48	33	66		
Use individual towel	No	53	98.15	36	72	>999.999	0.960
	Yes	1	1.85	14	28		
Fore stripping	No	43	79.63	43	86	0.482	0.308
	Yes	11	20.37	7	14		
CMT checking	No	51	94.44	43	86	1.973	0.453
	Yes	3	5.56	7	14		
Pre-dipping	No	0	0	0	0	-	-
	Yes	0	0	0	0		
Attach the cluster within 1 min	No	17	32.08	7	19.44	0.354	0.389
after udder preparation	Yes	36	67.92	29	80.56		
Post-dipping	No	38	70.37	28	56	0.688	0.768
	Yes	16	29.63	22	44		
Teat cup dipping	No	49	94.23	32	91.43	0.824	0.828
	Yes	3	5.77	3	8.57		
Use milk filter	No	0	0	0	0	-	-
	Yes	54	100	50	100		
Milk transportation by	No	0	0	21	42	<0.001	0.679
themselves	Yes	54	100	29	58		
Hand washing	No	29	53.70	18	36	0.909	0.885
	Yes	25	46.30	32	64		
Hand washing by water	No	30	55.56	19	38	1.167	0.812
	Yes	24	44.44	31	62		

Table 5 (continued)

Categorized variables	Categories	High SPC		Low SPC		OR	*p*-value
		N	%	N	%		
Hand washing by soap	No	53	98.15	49	98	<0.001	0.978
	Yes	1	1.85	1	2		
Milking technique	Machine milking	53	98.15	36	72	>999.999	0.976
	Hand milking	1	1.85	14	28		
Cleanliness of liner	Poor	23	43.40	8	22.86	3.333	0.083
	Good	30	56.60	27	77.14		
Cleanliness of long milk	Poor	9	16.98	4	11.43	2.361	0.296
tube	Good	44	83.02	31	88.57		
Cleanliness of milk tank	Poor	2	3.70	0	0	-	-
	Good	52	96.30	50	100		
Cleanliness of bulk tank	Poor	0	0	0	0	-	-
	Good	54	100	50	100		

Analysis of risk factors

The variables listed in Table 4-5 were screened for their association with low bacterial counts. Low bacterial counts at the MCC-level has four variables remaining as significant predictors in the final model as shown in Table 6. The likelihood ratio χ^2-value of the logistic model is 33.4159 (4 d.f., p<0.0001).

Table 6 Parameter estimates (β-coefficients) and odds ratios of significant predictors of high bacterial counts in raw milk at the milk collecting center level.

Factor	β-coefficients	S.E.[a]	P	aOR[b]	95% OR CI
Intercept	-4.2894	1.1078	-	-	-
Duration of dairy farming (years)	0.1286	0.0545	0.0184	1.137	1.022-1.265
Total milking cows	0.1986	0.0847	0.0191	1.220	1.033-1.440
Udder not dry before attachment	1.7608	0.5800	0.0024	5.817	1.867-18.129
Poor cleanliness of teat cup liner	1.8632	0.6408	0.0036	6.444	1.835-22.627

[a] S.E.: standard error.

[b] aOR: adjusted odds ratio.

Study B

Microbiological quality

The results of MB test in raw milk of all MCC were grading into 5 grades followed by the criteria of Dairy Farming Promotion Organization of Thailand (DPO) in 1996. The percentages of each grade are shown in Table 7, and the descriptive statistics of $\log_{10}$SPC, $\log_{10}$CC and $\log_{10}$LPC are shown in Table 8.

Table 7 Methylene blue reduction test in raw milk at the milk collecting center level (DPO, 1996)

Grade	Number	%
Grade1 (>6.0 hours)	3	1.14
Grade2 (4.0-6.0 hours)	84	31.82
Grade3 (3.0-4.0 hours)	98	37.12
Grade4 (2.0-3.0 hours)	73	27.65
Grade5 (<2.0 hours)	6	2.27
Total	264	100

Milk composition

The descriptive statistics of the percentages of Fat, Protein, Lactose, TS and SNF are in Table 8.

Somatic cell count

The descriptive statistics of somatic cell count are in Table 8.

Table 8 The descriptive statistics of log_{10}SPC[1], log_{10}CC[2], log_{10}LPC[3], Fat, Protein, Lactose, TS[4], SNF[5] and SCC[6] from 11 milk collecting centers (November 2001-October 2002)

Variable	Mean ±SE (min – max)	The descriptive data			
		N	First quartile	Median	Third quartile
Log_{10}SPC	6.144 ± 0.033 (5.240-7.000)	132	5.885	6.165	6.395
Log_{10}CC	4.277 ± 0.041 (3.180-5.990)	132	3.995	4.450	4.250
Log_{10}LPC	3.909 ± 0.059 (2.340-5.300)	125	3.370	3.910	4.420
Fat (%)	4.196 ± 0.025 (3.49-5.02)	121	4.02	4.17	4.38
Protein (%)	3.099 ± 0.006 (2.95-3.32)	121	3.06	3.10	3.14
Lactose (%)	4.716 ± 0.005 (4.56-4.85)	121	4.68	4.72	4.75
TS (%)	12.705 ± 0.026 (11.98 ± 13.60)	121	12.52	12.66	12.84
SNF (%)	8.511 ± 0.008 (8.23-8.77)	121	8.45	8.51	8.57
SCC (x 1000 cells/ml)	614.448 ± 18.942 (157.00-923.00)	81	543.75	628.00	718.00

[1]standard plate count [2]coliform count [3]laboratory pasteurization count
[4]total solid [5]solid not fat [6]somatic cell count

In addition, one-way ANOVA was conducted to find the differences in log_{10}SPC, log_{10}CC, log_{10}LPC, SCC, Fat, Protein, Lactose, Total solid and Solid not fat of every MCC and every month. The results of ANOVA are shown in Table 9. The result shows that log_{10}SPC, log_{10}CC, log_{10}LPC, SCC, Fat (%), Protein (%), Lactose (%), TS(%) and SNF (%) of each MCC are statistically significant difference (p <0.0001.).

However, only the log_{10}CC of each month is statistically significant different (p=0.0114). The graphs of log_{10}SPC, log_{10}CC, log_{10}LPC, SCC, Fat (%), Protein (%), Lactose (%), TS (%) and SNF (%) of each MCC from November 2001 to October 2002 are in Figure 10 – 18.

Table 9 Microbiological quality, milk composition and somatic cell count of bulk milk from monthly samples of 11 milk collecting centers

Data	Milk collecting center (mean ± SE)										
	1	2	3	4	5	6	7	8	9	10	11
Log_{10}SPC	6.609^{a}*	6.308^{bc}	6.188^{c}	5.705^{de}	6.255^{c}	6.242^{c}	6.090^{c}	6.277^{bc}	5.825^{d}	6.474^{ab}	5.608^{e}
	± 0.074	± 0.045	±0.048	±0.051	±0.086	±0.085	±0.052	±0.102	±0.057	±0.060	±0.076
	(N=25)	(N=26)	(N=24)	(N=24)	(N=23)	(N=24)	(N=23)	(N=22)	(N=23)	(N=24)	(N=24)
Log_{10}CC	4.623^{ab}	4.288^{bc}	4.246^{c}	3.845^{d}	4.414^{abc}	4.460^{abc}	4.194^{c}	4.285^{bc}	4.248^{c}	4.713^{a}	3.737^{d}
	±0.137	±0.071	±0.083	±0.048	±0.118	±0.087	±0.070	±0.232	±0.066	±0.081	±0.125
	(N=25)	(N=26)	(N=24)	(N=25)	(N=23)	(N=24)	(N=23)	(N=22)	(N=23)	(N=24)	(N=24)
Log_{10}LPC	3.864^{bc}	4.795^{a}	3.818^{bc}	3.966^{b}	4.066^{b}	3.534^{cd}	3.349^{de}	4.597^{a}	3.344^{de}	4.579^{a}	3.114^{e}
	±0.094	±0.083	±0.182	±0.116	±0.159	±0.090	±0.136	±0.073	±0.128	±0.114	±0.086
	(N=25)	(N=26)	(N=24)	(N=23)	(N=21)	(N=23)	(N=23)	(N=21)	(N=21)	(N=23)	(N=23)
Fat	4.266^{bc}	4.190^{cd}	4.022^{de}	4.289^{bc}	3.895^{e}	4.535^{a}	4.137^{cd}	4.048^{de}	4.175^{cd}	4.177^{cd}	4.418^{ab}
(%)	±0.089	±0.084	±0.055	±0.060	±0.062	±0.074	±0.039	±0.048	±0.048	±0.053	±0.106
	(N=23)	(N=25)	(N=22)	(N=20)	(N=20)	(N=21)	(N=22)	(N=19)	(N=20)	(N=20)	(N=21)
Protein	3.046^{c}	3.140^{b}	3.070^{c}	3.075^{c}	3.095^{bc}	3.201^{a}	3.125^{b}	3.070^{c}	3.058^{c}	3.067^{c}	3.143^{b}
(%)	±0.020	±0.011	±0.017	±0.013	±0.012	±0.027	±0.015	±0.019	±0.009	0.018	±0.012
	(N=23)	(N=25)	(N=22)	(N=20)	(N=20)	(N=21)	(N=22)	(N=19)	(N=20)	(N=20)	(N=21)

*The different letter in the same row means statistically significant different by one-way ANOVA ($p<0.05$).

Table 9 (continued)

Data	Milk collecting center (mean ± SE)										
	1	2	3	4	5	6	7	8	9	10	11
Lactose (%)	4.678^{c} ±0.021 (N=23)	4.699^{bc} ±0.012 (N=25)	4.730^{ab} ±0.014 (N=22)	4.681^{c} ±0.019 (N=20)	4.769^{a} ±0.016 (N=20)	4.732^{ab} ±0.013 (N=21)	4.760^{a} ±0.013 (N=22)	4.750^{a} ±0.015 (N=19)	4.684^{bc} ±0.012 (N=20)	4.695^{bc} ±0.013 (N=20)	4.700^{bc} ±0.017 (N=21)
TS (%)	12.685^{cd} ±0.081 (N=23)	12.718^{cd} ±0.079 (N=25)	12.512^{de} ±0.053 (N=22)	12.737^{c} ±0.059 (N=20)	12.452^{e} ±0.058 (N=20)	13.162^{a} ±0.069 (N=21)	12.715^{cd} ±0.040 (N=22)	12.563^{cde} ±0.049 (N=19)	12.609^{cde} ±0.050 (N=20)	12.632^{cde} ±0.062 (N=20)	12.972^{b} ±0.094 (N=21)
SNF(%)	8.424^{f} ±0.034 (N=23)	8.532^{cb} ±0.012 (N=25)	8.494^{cde} ±0.012 (N=22)	8.453^{def} ±0.018 (N=20)	8.559^{bc} ±0.015 (N=20)	8.631^{a} ±0.023 (N=21)	8.583^{ab} ±0.021 (N=22)	8.515^{cd} ±0.028 (N=19)	8.438^{ef} ±0.019 (N=20)	8.457^{def} ±0.025 (N=20)	8.539^{bc} ±0.017 (N=21)
SCC (x1000)	740.10^{a} ±54.74 (N=17)	687.17^{ab} ±36.75 (N=17)	736.65^{ab} ±32.10 (N=15)	483.20^{d} ±21.89 (N=17)	620.50^{bc} ±29.29 (N=16)	648.95^{ab} ±30.07 (N=15)	723.37^{ab} ±35.80 (N=15)	634.66^{abc} ±38.20 (N=16)	531.90^{cd} ±42.64 (N=16)	726.77^{ab} ±30.95 (N=13)	235.37^{e} ±27.23 (N=15)

*The different letter in the same row means statistically significant different by one-way ANOVA ($p<0.05$).

Antibiotic residue

The results of the antibiotic residue test in raw milk of all MCC are in Table 10

Table 10 Antibiotic residues in raw milk of all MCC from November 2001 to October 2002

Result	Number	%
1. Total	267	100
2. Negative	262	98.13
3. Positive	4	1.50
4. Doubtful	1	0.37

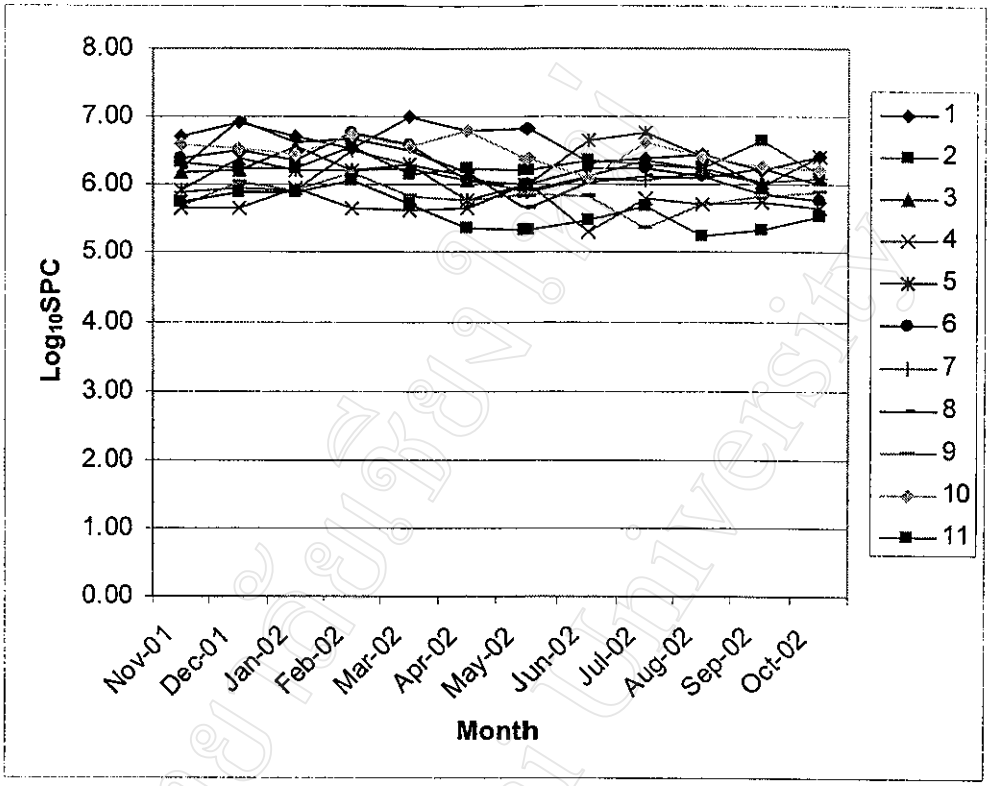

Figure 10 Log_{10} of standard plate count of each milk collecting center (1-11) from November 2001 to October 2002

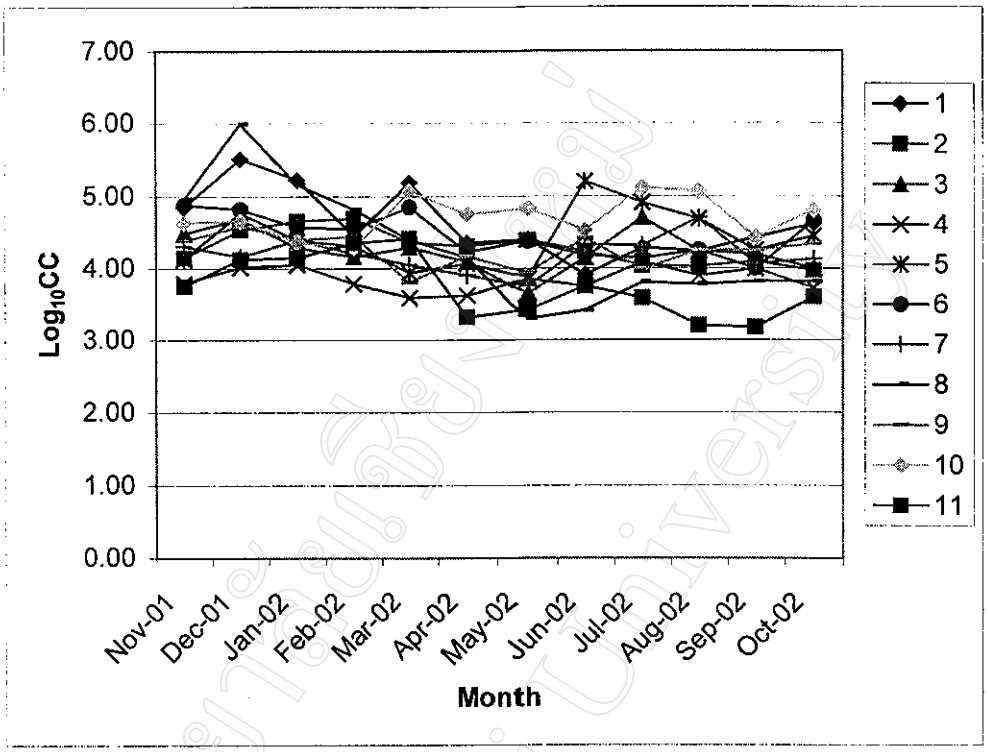

Figure 11 Log_{10} of coliform count of each milk collecting center (1-11) from November 2001 to October 2002 ($p \leq 0.05$ by one-way ANOVA)

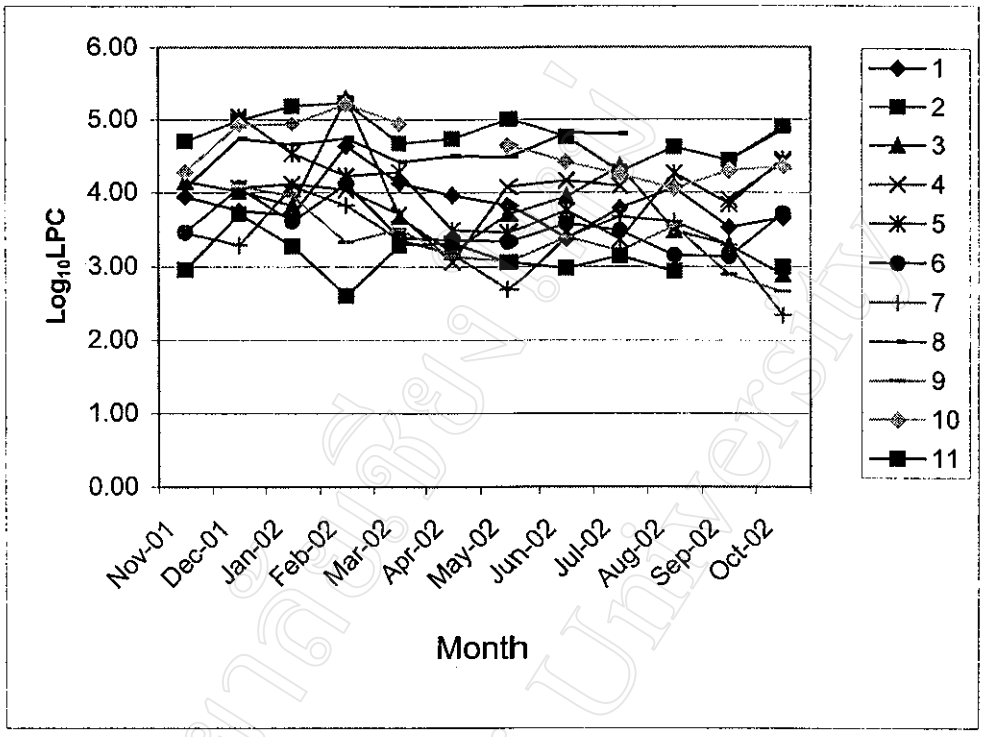

Figure 12 Log_{10} of laboratory pasteurization count of each milk collecting center (1-11) from November 2001 to October 2002

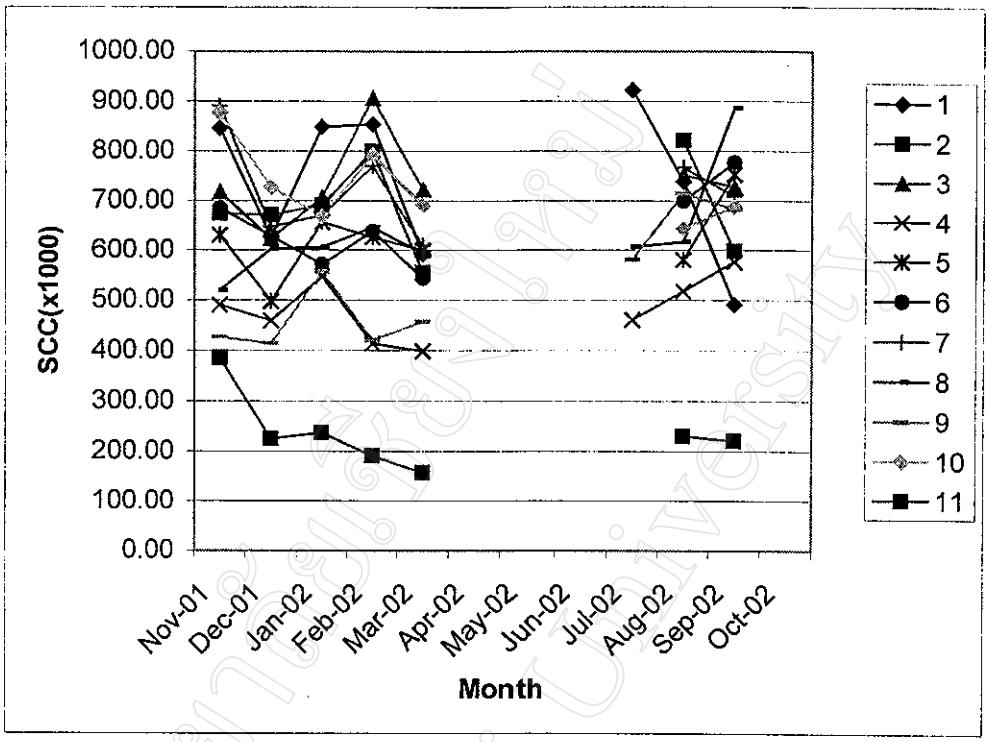

Figure 13 Somatic cell count of each milk collecting center (1-11) from November 2001 to October 2002

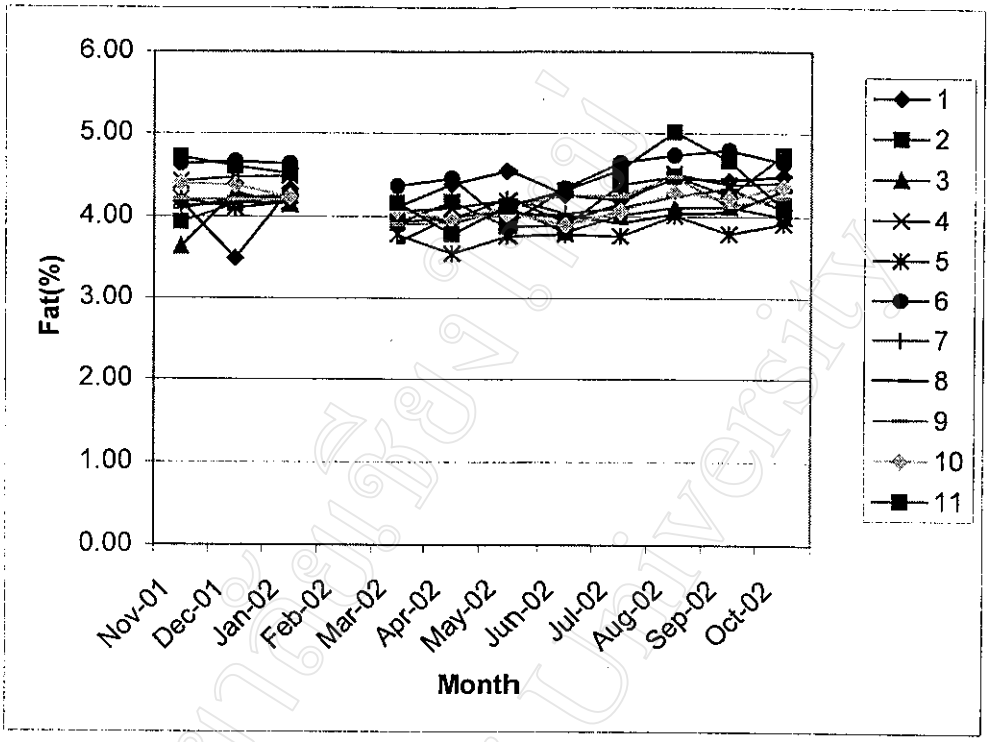

Figure 14 Fat (%) in raw milk of each MCC (1-11) from November 2001 to October 2002

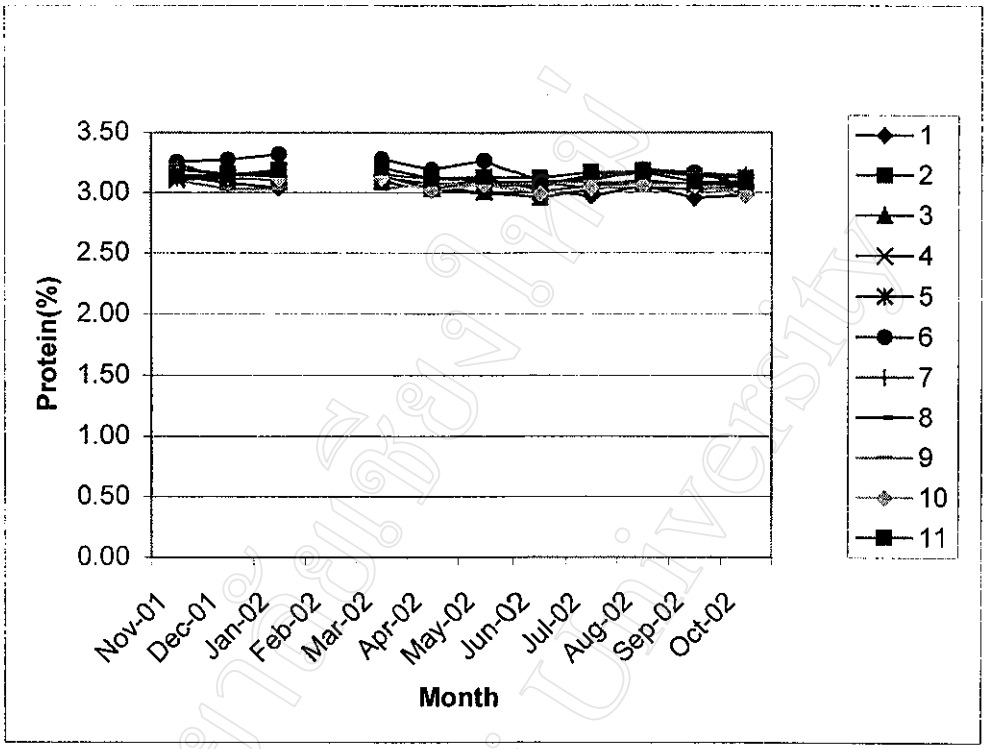

Figure 15 Protein (%) in raw milk of each MCC (1-11) from November 2001 to October 2002

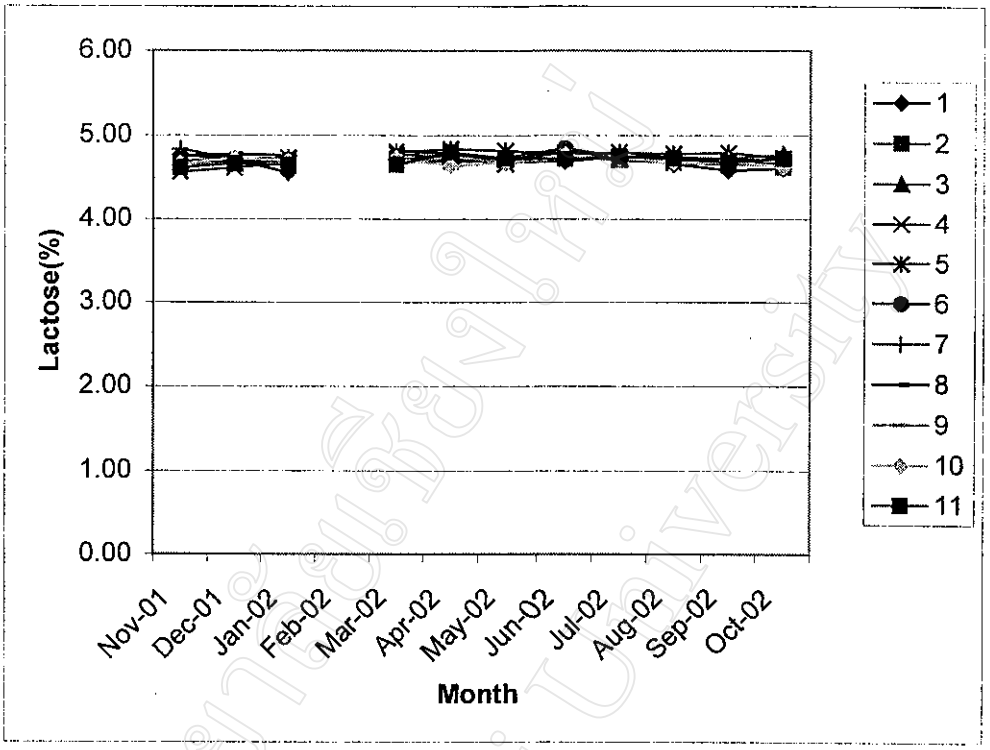

Figure 16 Lactose (%) in raw milk of each MCC (1-11) from November 2001 to October 2002

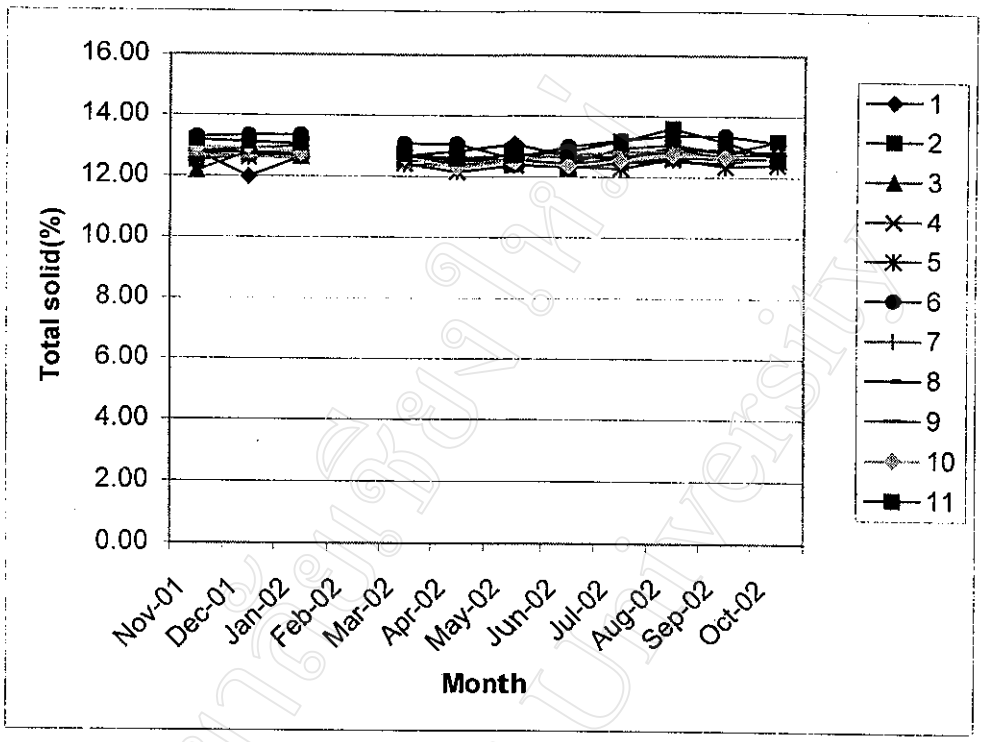

Figure 17 Total solid (%) in raw milk of each MCC (1-11) from November 2001 to October 2002

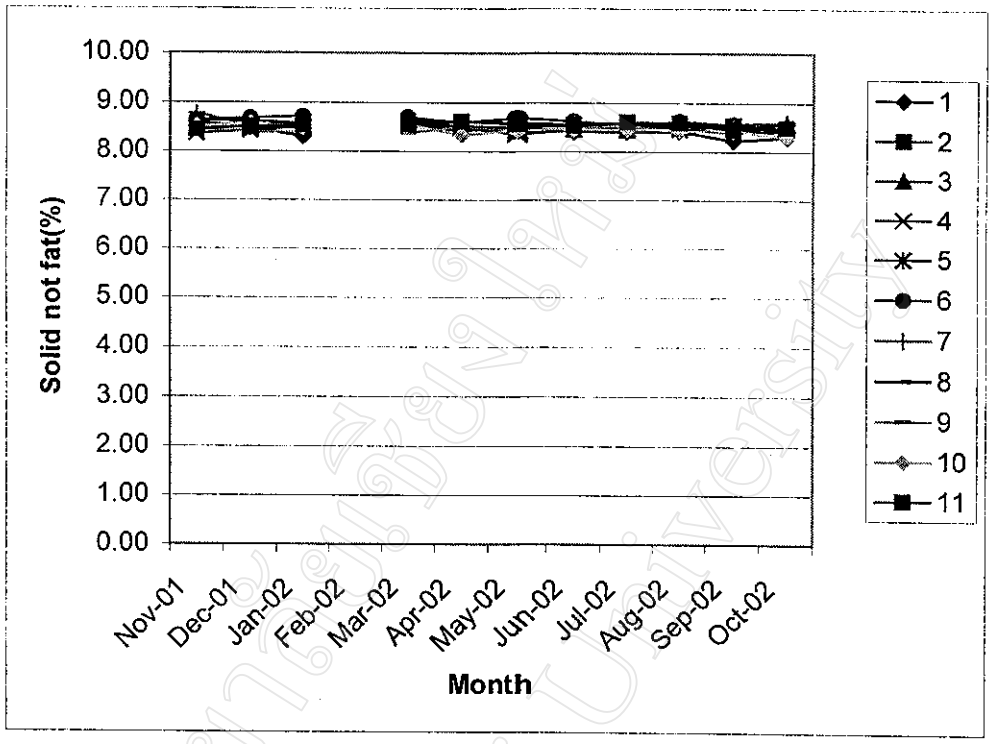

Figure 18 Solid not fat (%) in raw milk of each MCC (1-11) from November 2001 to October 2002

Study C

From the survey of the characteristics of the MCCs in Northern Thailand, the results show that the median of the total collected milk is 4.0 (1.2-13.6) ton/day and the number of the members is 52 (14-161) farms. All of the MCCs are operated by the dairy cooperatives, have 1-4 officers, receive milk twice a day (in the morning and in the evening). Each MCC has 1 – 2 cooling tanks which are 1.5 - 10 ton in size, the temperature are set at –0.3 to 7 °C and take about 0 – 8 hours to decrease the temperature of the raw milk to set point. All MCCs use the alcohol test for receiving system. About the pricing system, all MCCs use the methylene blue reduction test to determine it and some MCCs add the others, such as the resazurin test, to determine it.

About the laboratory data, the SPC was transformed to the $\log_{10}$SPC which were 5.551-6.787. The median of $\log_{10}$SPC was 6.20 (1,584,962 cfu/ml). So, the MCCs were divided into 2 groups; group1 $\log_{10}$SPC>6.20 and group2 $\log_{10}$SPC≤6.20. The results of MCCs' characteristics are shown in Table 11 and Table 12.

The median of ratio of total capacity of cooling tanks: total milk weight of each of the MCC was calculated, and this value was 1.5. The MCCs are divided into 2 groups by this value; group1 the ratio ≥1.5 and group2 the ratio <1.5. The relationship of the group of SPC and group of this ratio cannot be found (Fisher exact test; 2-tailed $p = 0.061$).

Table 11 Milk collecting center's characteristics in northern Thailand (continuous data)

Continuous data	Total (n = 11)	Group1 (n = 6)	Group2 (n = 5)
	Median (min-max)	Mean (min-max)	Mean (min-max)
Number of members (member)	52 (14-161)	55.7 [a]* (14-146)	90.2 [a]* (25-161)
Collection duration of each member**(min)	3.46 (0.82-10.71)	4.33 [a] (0.82-10.71)	1.96 [a] (0.75-3.60)
Total milk weight (x 1000 kg.)	4 (1.2-13.6)	4.5 [a] (1.2-12.0)	7.9 [a] (2.4-13.6)
Total capacity of cooling tank /total milk weight	1.5 (0.81-5.00)	1.72 [a] (0.81-5.00)	1.71 [a] (1.47-2.50)

* The same letters in the same row represented that the mean from group1 is not statistically different from group2 ($p \leq 0.05$) by Two sample T-test.

** This is the ratio of total collection duration / numbers of members.

Table 12 Milk collecting center's characteristics in northern Thailand (categorized data)

Categorized data	Category	N	%
Management style	Private	0	0
	Cooperative	11	100
	Academic	0	0
	Others	0	0
Test for receiving	Antibiotic residue test	5	45.45
	Alcohol test	11	100
	Specific gravity test	2	18.18
	Others	1	9.09
Test for pricing	Methylene blue reduction test	11	100
	Resazurin test	6	54.55
	Antibiotic residue rest	3	27.27
	Transportation duration	3	27.27
	Barn score	0	0
	Total solid	1	9.09
	Somatic cell count	6	54.55
	Others	6	54.55
Cleaned water for cleaning the member's bulk tank	No	3	27.27
	Yes	8	72.73
CIP system	No	1	9.09
	Yes	10	90.91
Floor condition	Wet	6	54.55
	Dry	5	45.45