

Milk quantity, quality and revenue in dairy farms supported by a private organization in Central Thailand

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Abstract

This study evaluated factors affecting milk yield per farm and per cow, milk quality (percent of fat, protein, lactose, solid-not-fat, and total solids and somatic cell count), and revenue per farm and per cow in dairy farms supported by a private organization in Central Thailand. The dataset included 34,133 monthly farm records collected from September 2003 to December 2007. Seasons were defined as winter, summer and rainy. Farms were located in Muak Lek, Wang Muang, Phattana Nikhom and Pak Chong districts. Farm sizes were classified as small, medium and large based on number of cows milked per day. The model for each trait contained year-season and farm location-farm size as subclass fixed effects, and individual farm and residual as random effects.

All traits were affected by year-season and farm location-farm size effects, except for protein percentage. Monthly milk yield per farm and per cow tended to decrease and somatic cell count tended to increase from 2003 to 2007. Milk production per cow was similar across farm sizes and locations. Large farms had higher somatic cell counts than small and medium farms. Revenues per farm and per cow depended primarily on milk yields per farm and per cow. Better training, support and commercial opportunities for farmers are needed to stimulate improvements in dairy production and farm revenues in Central Thailand.

Key words: dairy farming, economic, production, tropics

Introduction

The main objectives of the dairy promotion program in Thailand are to increase milk quantity, milk revenue and milk quality as well as to increase product safety and satisfaction of consumers. Despite considerable efforts on the part of the government, private organizations and dairy farmers, 305-day milk production in Thailand only averages $3,900 \pm 1,100$ kg (Dairy Farming Promotion Organization 2007). Although milk consumption, number of dairy farms, total quantity of dairy products and land used for dairy production have all increased yearly since the beginning of dairy production in Thailand, progress in terms of milk quality and efficiency of production has been slow (Dairy Farming Promotion Organization 2007; Office of Agricultural Economics 2008).

Dairy farming has become an increasingly competitive business in Thailand, due particularly to importation of dairy products (e.g., powdered milk and butter) from other countries (i.e., Australia and New Zealand) as a result of international free trade agreements (Department of

Trade Negotiations 2005; Office of Agricultural Economics 2008). Survival of dairy farming in Thailand depends on the ability of dairy farmers to increase the profitability and efficiency of their dairy operations. Revenues are directly related to amount of milk produced. In addition, milk quality factors (fat percentage, bacterial contamination and somatic cell count) also impact the price of raw milk paid to dairy producers (Muak Lek Dairy Cooperative Limited 2005). Thus, both quantity and quality of milk determine the amount of revenue of dairy farmers in Thailand (Seangjun and Koonawootrittriron 2007; Rhone et al 2008b, c).

The central area is the most important dairy region in Thailand. In 2006, this region had 12,253 dairy households (60% of the country), 280,289 dairy cattle (68% of the country), and 113,080 milking cows (69% of the country) that produced 805,083 kg of milk per day (66% of the country). In addition, there were 14 dairy cooperatives and 17 private organizations in this region (Department of Livestock Development 2007). The role of dairy cooperatives and private organizations is to purchase milk from dairy farmers and to provide services to their members. Dairy cooperatives belong to farmers, are supported by the government, and are managed by a committee of elected farmers. In contrast, private dairy organizations belong to a business person who also manages the business and makes decisions. Although these two types of organizations have similar objectives, they could have dissimilar performance because of different management styles.

Under the current social conditions and high level of economic competition in Thailand, increasing efficiency and lowering production costs while producing high quality milk would increase farmer profitability. Determination of important factors affecting milk quantity and quality would help dairy farmers manage their limited resources more effectively and provide opportunities to increase the efficiency of their dairy operations. This information would also help dairy organizations to provide more appropriate and effective support to their members. Studies on factors affecting milk quantity and quality in Central Thailand have been conducted to date only for members of a dairy cooperative (Seangjun and Koonawootrittriron 2007; Rhone et al 2008b, c). Similar studies for members of a dairy private organization do not exist. Thus, the objective of this research was to determine factors affecting milk quantity, quality and revenue in dairy farms supported by a private organization in the Central Thailand.

Materials and methods

Data, traits and farms

The dataset was composed of 34,133 farm records of milk production, revenue and quality. These records were from 1,101 farms supported by a private dairy organization (Midland Dairy Limited Partnership, Saraburi, Thailand) from September 2003 to December 2007. No records were taken from individual animals.

The dataset contained farm records for 2 monthly milk production traits, 2 monthly milk revenue traits and 6 monthly milk quality traits. The 2 monthly milk production traits were milk yield per farm (MYF; kg) and milk yield per cow (MYC; kg). MYF was computed as the sum of daily milk yields per farm for each month. MYC was calculated by dividing MYF by the average number of milking cows for a particular farm and month.

The 2 monthly milk revenue traits were milk revenue per farm (RVF; baht) and milk revenue per cow (RVC; baht). The average exchange rate during the years of the study was 37.71 ± 2.54 baht per USD. RVF was the amount of money that farms received from selling their milk to the private dairy organization for each month. RVF was computed as the sum of daily milk income per farm for each month. RVC was calculated by dividing RVF by the average number of milking cows for a particular farm and month.

The monthly milk quality traits were fat percentage (FAT; %), protein percentage (PRO; %), lactose percentage (LAC; %), solids-not-fat percentage (SNF; %), total-solids percentage (TS; %) and somatic cell count (SCC; $\times 10^3$ cells/ml). The values of FAT, PRO, LAC, SNF, TS and SCC were obtained from milk samples taken randomly once a month from milk containers from individual farms.

The farm identification number created by the private dairy organization was used for the analyses and also to link all related information. The address of individual farms was used to assign farms to 4 locations: Muak Lek (Saraburi province), Wang Muang (Saraburi province), Phattana Nikhom (Lop Buri province) and Pak Chong (Nakhon Rachasima province). The average number of milking cows for the duration of the study was used to classify farms into 3 sizes: small = less than 10 milking cows per day, medium = between 10 and 19 milking cows per day and large = 20 or more milking cows per day). Seasons were winter (November to February: cool [21 °C to 32 °C] and dry [70% RH, precipitation 124 mm/year]), summer (March to June: hot [25 °C to 36 °C] and dry [69% RH, precipitation 187 mm/year]) and rainy season (July to October: hot [24 °C to 33 °C] and humid [79% RH, precipitation 903 mm/year]) as described by Koonawootrittriron et al 2009).

Cattle, feeding and management practices

The majority of dairy cattle in the population were over 75% Holstein (H). The remaining fraction (25% or less) contained genes from one or more of the following breeds: Brahman, Jersey, Red Dane, Red Sindhi, Sahiwal and Thai Native. Farms primarily used artificial insemination (AI) to breed cows. Most farms used semen from Holstein bulls to breed cows. Farmers used their own experience, sire information (EBV and daughters' production) and suggestions from government and private organization advisors to choose sires. The private organization provided veterinary services to farms including AI and healthcare for animals. Calves were vaccinated against Hemorrhagic Septicemia between 4 and 8 months of age. All animals were vaccinated against Foot and Mouth Disease twice a year. All farms treated their cows with antihelmintics twice a year.

Farm feeding and nutritional management varied among seasons. Grasses fed to dairy cattle included *Brachiaria mutica* (para grass), *Brachiaria ruziziensis* (ruzi grass), *Pennisetum purpureum* (napier grass) and *Panicum maximum* (guinea grass). However, during the dry seasons (cold and hot) grasses were usually insufficient because of lack of irrigation. Thus, rice straw, hay and silage were used as supplements. All farmers milked cows twice a day, once in the morning and once in the afternoon. Almost all farms used machine rather than hand milking. After each milking, either the farmer or a private carrier took the raw milk to the private milk collection center.

The volume of milk received from each farm after each milking (morning and afternoon) was recorded at the private milk collecting center. Milk from individual farms was randomly sampled every ten days. Milk samples were sent to the Department of Livestock

Development office for milk quality analyses (i.e., FAT, PRO, LAC, SNF, TS and SCC). If a farm had low milk quality (i.e., FAT < 3.2%, PRO < 2.8%, SNF < 8.25%, TS < 12% or SCC > 500×10^3 cells/ml), then personnel from the private organization visited that farm and provided suggestions to solve the problems that were identified (e.g., improvements in feeding, housing or milking conditions; Midland Dairy Limited Partnership 2007).

Statistical analysis

Single-trait mixed models were used to analyze MYF, MYC, RVF, RVC, FAT, PRO, LAC, SNF, TS and SCC. Computations were carried out using the mixed procedure of the SAS software package (SAS 2004). The mixed model used for all traits contained the subclasses of year-season and farm location-farm size as fixed effects. Year-season subclasses contained the effects of year, season and year $\times$ season interactions. Similarly, farm location-farm size subclasses contained the effects of farm location, farm size and farm location $\times$ farm size interactions. Random effects were farm and residual. The model in matrix notation was as follows.

$$y = Xb + Z_f u_f + e$$

where

- y = vector of single-trait records (MYF, MYC, RVF, RVC, FAT, PRO, LAC, SNF, TS or SCC),
- b = vector of fixed effects (year-season and farm location-farm size),
- u_f = vector of random farm effects,
- X = incidence matrix relating records to elements of b ,
- Z_f = incidence matrix relating records to elements of u ,
- e = vector of residual effects.

Random farm effects were assumed to have mean zero, a common variance σ_f^2 and uncorrelated. Similarly, random residual effects were assumed to have mean zero, common variance σ_e^2 and uncorrelated. Variances for random effects were estimated using restricted maximum likelihood using option REML in the mixed procedure of SAS. Year-season and farm location-farm size least squares means (LSM) were estimated for all traits, and then compared using t-tests.

Results and discussion

Milk yield, quality and revenue of dairy farms included in this study were as shown in Table 1.

Table 1. Number of observation, mean and standard deviation of milk quantity, milk quality and revenue

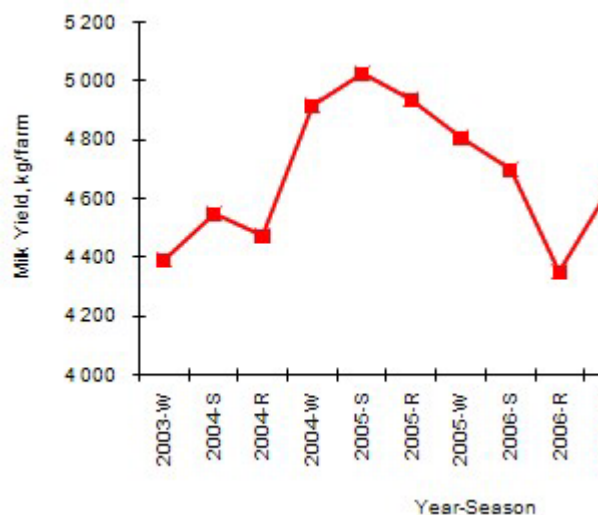
Trait	Number of observations	Mean	Standard deviation
Milk yield per farm, kg	23,052	3,232	2,553
Milk yield per cow, kg	23,052	367	163
Revenue per farm, baht	23,052	37,522	29,850
Revenue per cow, baht	23,052	4,256	1,895
Fat, %	28,612	3.40	0.46
Protein, %	28,729	3.01	0.22
Lactose, %	28,727	4.57	0.28
Solid not fat, %	28,729	8.25	0.36

Total solid, %	28,700	11.7	0.67
Somatic cell count, $\times 10^3$ cells/ml	26,103	657	679

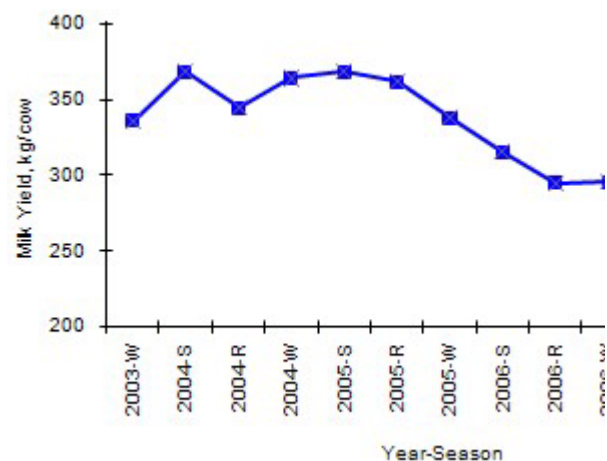
Averages for these traits were similar to those from farms supported by a dairy cooperative in Central Thailand (Seangjun and Koonawootrittriron 2007; Rhone et al 2008a, b, c)

Year-season subclass effects

Year-season LSM ranged from $4,352 \pm 89.5$ kg (2006-Rainy) to $5,027 \pm 84.7$ kg (2005-Summer) for MYF (Figure 1a) and from 284 ± 7.73 kg (2007-Rainy) to 369 ± 6.63 kg (2005-Summer) for MYC (Figure 1b). Year-season LSM for MYF tended to increase from 2003 to 2007 (4.57 ± 17.0 kg/year-season; $P < 0.79$; $P > 0.05$). In contrast, year-season LSM for MYC decreased over this same period (-6.23 ± 1.42 kg/year-season; $P < 0.01$). These trends for MYF and MYC indicated that the increase in milk production per farm that occurred in this dairy cattle population from 2003 to 2007 was not because of an increase in individual MYC, but it was due to an increase in the average number of cows milked per day. The average number of cows milked per day increased from 8.54 ± 6.31 cows in 2003 to 10.7 ± 7.80 cows in 2007.



(a)



(b)

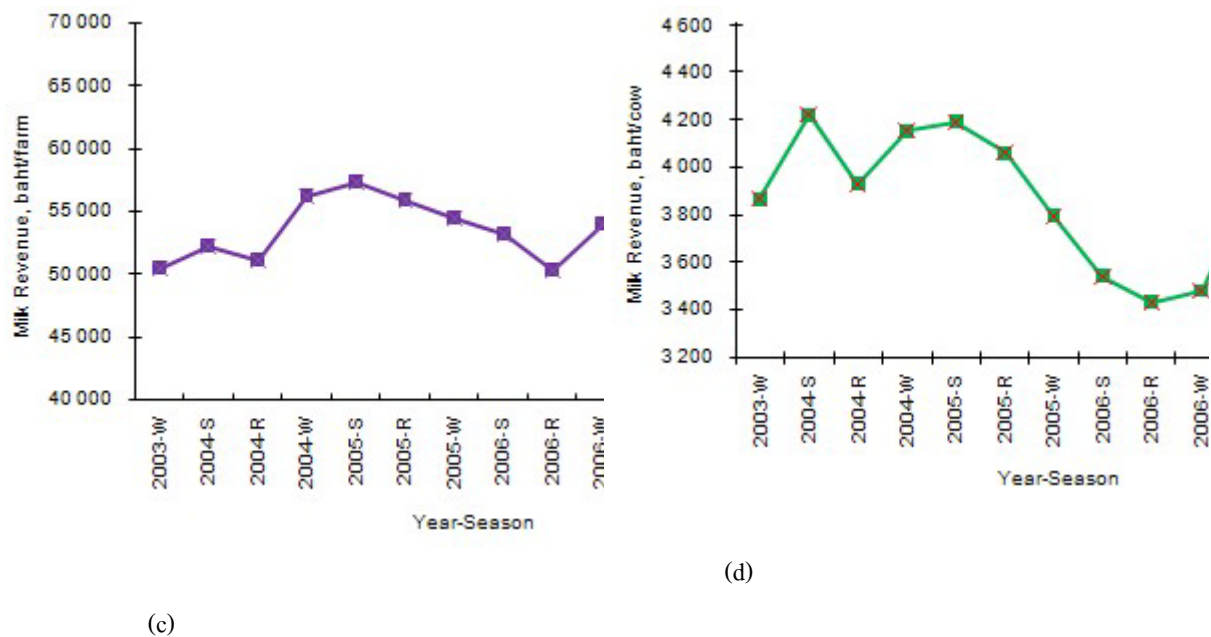


Figure 1. Year-season subclass least squares means for monthly milk yield per farm (a), milk yield per cow (b), milk revenue per farm (c) and milk revenue per cow (d)

Year-season LSM for farm revenues ranged from $50,322 \pm 1,044$ baht (2006-Rainy) to $65,441 \pm 1,155$ baht (2007-Winter) for RVF (Figure 1c), and $3,430 \pm 87$ baht (2006-Rainy) to $4,435 \pm 104$ baht (2007-Winter) for RVC (Figure 1d). There was a positive trend of 623 ± 249 baht/year-season ($P < 0.03$) for RVF from 2003 to 2007. On the other hand, RVC tended to decrease (-15 ± 23 baht/year-season; $P < 0.53$) between 2003 and 2007. The direction of the RVF and RVC trends were the same as those for MYF and MYC. This occurred because the milk revenue system in Thailand depends primarily on milk quantity, thus revenues are proportional to amounts of milk purchased by milk collection centers.

The decreasing trend in MYC found in this dairy population between 2003 and 2007 may have been a consequence of the deterioration of the economic situation of dairy farmers during that period. The price for raw milk yield remained at 12.5 baht/kg from September 2003 to September 2007 (Office of Agricultural Economics 2008; Department of Livestock Development 2007). However, dairy production costs (e.g., feed, fuel, labor, equipment and services) and living expenses (e.g., food, clothes and health care) increased dramatically from 2003 to 2007 (Prateepavanid 2006; Suriyasathaporn et al 2006; Ndambi et al 2008). In order to maintain their revenue the farmers were forced to increase their farm size which could have also led to their inability to supply the required inputs for production. Increased costs may have forced farmers to decrease the quantity and quality of feed supplied to cows, and perhaps to lower the level of management and health care. Decreased levels of nutrition, management, and health care may, in turn, have increased stress on dairy cows resulting in lower MYC.

Price of milk was increased to 14.5 baht during the last quarter of 2007 (Office of Agricultural Economics 2008; Department of Livestock Development 2007). Information collected from dairy farms in this study in 2008 and later years will help determine whether this price increase for milk resulted in a corresponding increase in MYC. Additional training on improving the efficiency of milk production, cost-effective feeding, management and

health care practices of dairy farmers in this private organization may also help increase the productivity and profitability of their dairy farms.

Table 2 shows LSM and standard errors for the 6 milk quality traits (FAT, PRO, LAC, SNF, TS and SCC) by year-season subclass.

Table 2. Least squares means for fat (FAT), protein (PRO), lactose (LAC), solids not fat (SNF), total solids (TS) and somatic cell count (SCC) by year-season subclass

Year-Season subclass	Milk quality						SCC, $\times 10^3$ cells/ml
	FAT, %		PRO, %		LAC, %		
2003 - Winter	3.48	$\pm$	3.13	$\pm$	4.61	$\pm$	674 $\pm$ 26.5
	0.017 ^a		0.008		0.008		
2004 - Summer	3.50	$\pm$	3.09	$\pm$	4.61	$\pm$	770 $\pm$ 24.3
	0.016		0.007		0.007		
2004 - Rainy	3.31	$\pm$	2.90	$\pm$	4.01	$\pm$	755 $\pm$ 25.0
	0.016		0.008		0.007		
2004 - Winter	3.36	$\pm$	2.93	$\pm$	4.33	$\pm$	672 $\pm$ 24.6
	0.016		0.007		0.007		
2005 - Summer	3.39	$\pm$	2.99	$\pm$	4.62	$\pm$	799 $\pm$ 30.9
	0.019		0.009		0.008		
2005 - Rainy	3.45	$\pm$	3.08	$\pm$	4.64	$\pm$	736 $\pm$ 26.2
	0.017		0.008		0.008		
2005 - Winter	3.46	$\pm$	2.95	$\pm$	4.61	$\pm$	764 $\pm$ 25.0
	0.016		0.008		0.007		
2006 - Summer	3.41	$\pm$	3.02	$\pm$	4.66	$\pm$	775 $\pm$ 24.8
	0.016		0.008		0.007		
2006 - Rainy	3.52	$\pm$	3.10	$\pm$	4.65	$\pm$	795 $\pm$ 27.6
	0.018		0.008		0.008		
2006 - Winter	3.52	$\pm$	3.02	$\pm$	4.68	$\pm$	740 $\pm$ 26.1
	0.017		0.008		0.008		
2007 - Summer	3.42	$\pm$	3.02	$\pm$	4.71	$\pm$	843 $\pm$ 24.9
	0.016		0.008		0.007		
2007 - Rainy	3.68	$\pm$	3.12	$\pm$	4.68	$\pm$	868 $\pm$ 24.5
	0.016		0.008		0.007		
2007 - Winter	3.59	$\pm$	3.05	$\pm$	4.63	$\pm$	838 $\pm$ 28.0
	0.018		0.009		0.008		

^a Standard error

Year-season LSM tended to increase for FAT ($0.015 \pm 0.006\%$ /year-season; $P < 0.04$), LAC ($0.024 \pm 0.013\%$ /year-season; $P < 0.09$), SNF ($0.021 \pm 0.016\%$ /year-season; $P < 0.21$), TS ($0.033 \pm 0.021\%$ /year-season; $P < 0.13$) and SCC ($11.31 \pm 3.07 \times 10^3$ cells/ml/year-season; $P < 0.01$), and to remain unchanged for PRO ($0.003 \pm 0.006\%$ /year-season; $P < 0.58$). Similar trends across year-seasons for milk quality traits were also found by Azad et al (2007), Seangjun and Koonawootrittriron (2007) and Rhone et al (2008a).

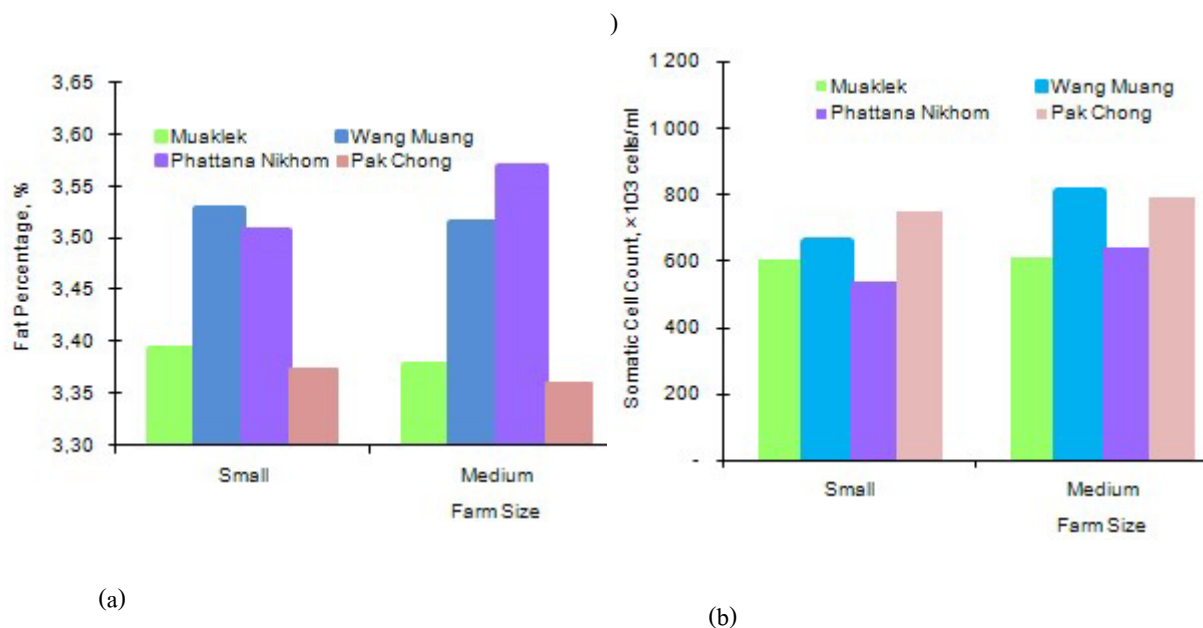
Trends for milk quality traits in this dairy population were low but favorable, except for SCC. Year-season LSM for SCC were all above the recommended maximum of 500,000 cells/ml (Department of Livestock Development 2003; Thai Agriculture Commodity and Food Standard 2005). Thus, improving management and health care of dairy cows to reduce and maintain SCC below the recommended maximum should be a priority for farmers in this private organization. This will likely result not only in lower SCC, but it may also increase milk production.

All milk quality traits were likely influenced by quantity and quality of roughage, management, health care (particularly for SCC) and changing climatic conditions across years and seasons. Thus, variability in environmental conditions across year-seasons should be accounted for when devising management strategies to improve milk quality in Central Thailand.

Farm location-farm size subclass effects

Farm location-farm size subclass was important for all traits ($P < 0.05$; Figure 2a). Farm location-farm size LSM for MYF ranged from $6,157 \pm 625$ kg in Phattana Nikhom to $8,675 \pm 228$ kg in Muak Lek for large farms, from $4,113 \pm 286$ kg in Phattana Nikhom to $4,759 \pm 194$ kg in Pak Chong for medium farms and from $1,566 \pm 188$ kg in Phattana Nikhom to $1,823 \pm 135$ kg in Pak Chong for small farms.

Farm location-farm size subclass LSM for MYC ranged from 162 ± 47.4 kg in Phattana Nikhom to 356 ± 17.3 kg in Muak Lek for large farms, from 319 ± 22.1 kg in Phattana Nikhom to 378 ± 14.5 kg in Pak Chong for medium farms and from 337 ± 14.7 kg in Phattana Nikhom to 353 ± 10.2 kg in Pak Chong for small farms. Except for large farms in Phattana Nikhom, ranges for MYC were similar in all farm location by farm size (Figure 2b).



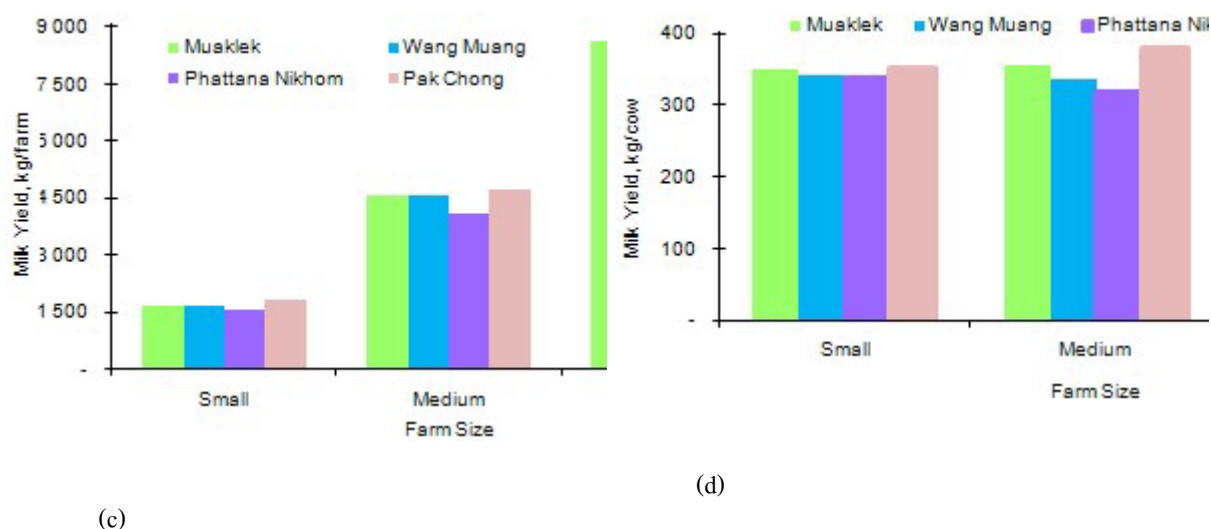


Figure 2. Farm location-farm size subclass least squares means for monthly milk yield per farm (a), milk yield per cow (b), milk revenue per farm (c) and milk revenue per cow (d)

The low LSM values for MYF and MYC in large farms in Phattana Nikhom was likely due to the low quality and quantity of feed provided to dairy cows. Large farms in Phattana Nikhom made extensive use of rice straw particularly during the dry season because of limited availability and high cost of good quality forage. Most farms in Phattana Nikhom (82%) did not grow grass or legume for their cows, and approximately 84% of the land in Phattana Nikhom was used for crop production (cassava, sugarcane, corn and sunflower).

The pattern of farm location-farm size LSM for RVF across locations was similar to that for MYF (Figure 2c). Farm location-farm size LSM for RVF ranged from $72,015 \pm 7,273$ baht in Phattana Nikhom to $100,929 \pm 2,655$ baht in Muak Lek for large farms, from $47,987 \pm 3,334$ baht in Phattana Nikhom to $56,338 \pm 2,253$ baht in Pak Chong for medium farms and from $19,449 \pm 2,184$ baht in Phattana Nikhom to $21,960 \pm 1,574$ baht in Pak Chong for small farms.

A similar pattern of farm location-farm size LSM across locations existed for RVC (Figure 2d) and MYC (Figure 2b). In particular, large farms in Phattana Nikhom had lower RVC as expected from the low LSM for MYC and the milk pricing system in Thailand. Farm location-farm size LSM for RVC ranged from $2,015 \pm 549$ baht/cow in Phattana Nikhom to $4,208 \pm 200$ baht/cow in Muak Lek for large farms, from $3,757 \pm 256$ baht/cow in Phattana Nikhom to $4,484 \pm 168$ baht in Pak Chong for medium farms and from $3,996 \pm 171$ baht/cow in Phattana Nikhom to $4,179 \pm 118$ baht/cow in Pak Chong for small farms.

The RVF and RVC patterns across farm location-farm size subclasses were related to MYF and MYC. Low milk revenues (RVF and RVC) were due to low milk production (MYF and MYC) rather than low milk quality (FAT, PRO, LAC, SNF, TS and SCC). Thus, factors that affected milk production (e.g., feed and management) had a direct impact on milk revenues. As with MYF and MYC, low LSM values for RVF and RVC in large farms in Phattana Nikhom were likely due to low quality and quantity of feed given to cows. Thus, feed and management strategies, especially during the dry season, must be improved to increase milk production and revenues in this region.

Table 3 shows LSM for FAT, PRO, LAC, SNF, TS and SCC by farm location-farm size subclass.

Table 3. Least squares means for fat (FAT), protein (PRO), lactose (LAC), solids not fat (SNF), total solids (TS) and somatic cell count (SCC) by farm location-farm size subclass

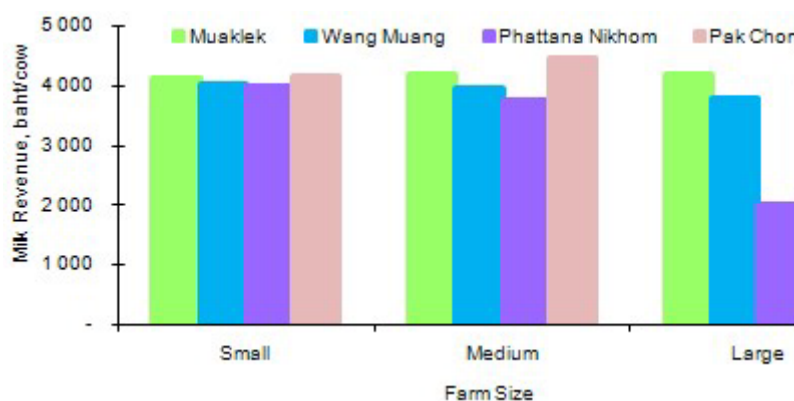
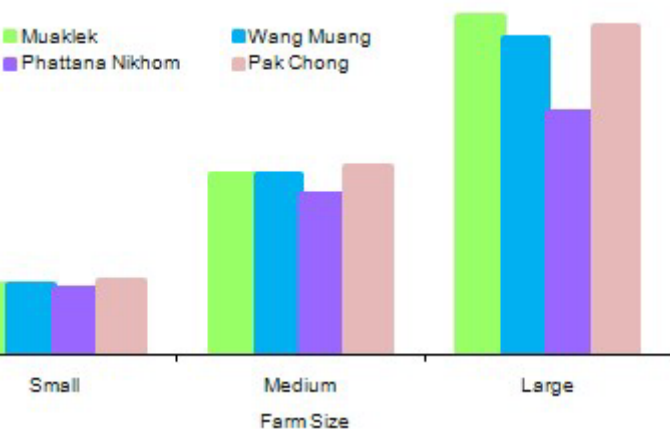
Farm location ^a	Farm size ^b	Milk Quality											
		FAT, %		PRO, %		LAC, %		SNF, %		TS, %		SCC, cells/ml	×10 ³
ML	Small	3.39	±	3.02	±	4.58	±	8.26	±	11.74	±	602 ± 17.6	
		0.011 ^c		0.005		0.005		0.008		0.016			
	Medium	3.38	±	3.01	±	4.59	±	8.26	±	11.73	±	611 ± 25.1	
		0.016		0.008		0.007		0.012		0.022			
	Large	3.44	±	3.03	±	4.55	±	8.24	±	11.77	±	744 ± 65.2	
		0.042		0.021		0.020		0.031		0.059			
WM	Small	3.53	±	3.04	±	4.59	±	8.29	±	11.92	±	659 ± 36.5	
		0.023		0.012		0.011		0.017		0.032			
	Medium	3.51	±	3.02	±	4.58	±	8.26	±	11.86	±	809 ± 62.3	
		0.040		0.020		0.019		0.029		0.056			
	Large	3.55	±	3.07	±	4.55	±	8.28	±	11.93	±	1,056 ± 103	
		0.067		0.033		0.031		0.049		0.093			
PN	Small	3.51	±	3.02	±	4.61	±	8.30	±	11.90	±	536 ± 48.5	
		0.031		0.016		0.014		0.023		0.043			
	Medium	3.57	±	3.03	±	4.59	±	8.28	±	11.95	±	639 ± 74.4	
		0.048		0.024		0.022		0.035		0.066			
	Large	3.60	±	3.09	±	4.58	±	8.33	±	12.01	±	1,000 ± 154	
		0.098		0.049		0.046		0.072		0.137			
PC	Small	3.37	±	3.02	±	4.53	±	8.21	±	11.67	±	749 ± 40.1	
		0.025		0.013		0.012		0.018		0.036			
	Medium	3.36	±	2.99	±	4.54	±	8.19	±	11.64	±	792 ± 56.4	
		0.036		0.018		0.017		0.027		0.050			
	Large	3.41	±	3.05	±	4.56	±	8.27	±	11.77	±	1,063 ± 114	
		0.073		0.037		0.034		0.054		0.102			

^aML = Muak Lek; WM = Wang Muang; PN = Phattana Nikhom; PC = Pak Chong

^bSmall = less than 10 milking cows per day; Medium = from 10 to 19 milking cows per day; Large = 20 or more milking cows per day; ^c Standard error

Farm location-farm size subclass LSM for FAT, PRO, SNF, TS and SCC tended to be similar in small and medium farms ($P > 0.05$) and smaller than in large farms ($P < 0.05$) in almost all locations. In contrast, LSM for LAC tended to decrease as farm size increased in all locations, except for Pak Chong.

Values of LSM for FAT across farm location-farm size subclasses ranged from $3.41 \pm 0.07\%$ in Pak Chong to $3.60 \pm 0.10\%$ in Phattana Nikhom for large farms, from $3.36 \pm 0.04\%$ in Pak Chong to $3.57 \pm 0.05\%$ in Phattana Nikhom for medium farms and from $3.37 \pm 0.03\%$ in Pak Chong to $3.53 \pm 0.02\%$ in Wang Muang for small farms. Large farms in Muak Lek, Pak Chong and Wang Muang tended to have similar and higher FAT than small and medium farms. All farm sizes in Muak Lek had LSM for FAT similar to those in Pak Chong and both of them were lower than FAT values of farms in Phattana Nikhom and Wang Muang (Figure 3a). Variability of FAT across farm location-farm size subclasses could be associated with weather patterns, availability of roughage, agricultural activities, irrigation of pastures and the ability of farmers to manage and utilize local feed resources (Allore et al 1997; Kaewkamcham et al 2001; Garcia et al 2005).



(b)

location-farm size subclass least squares means for fat percentage (a) and somatic cell count (b)

Farm location-farm size LSM for SCC ranged from $744 \pm 65.2 \times 10^3$ cells/ml in Muak Lek to $1,063 \pm 114 \times 10^3$ cells/ml in Pak Chong for large farms, from $611 \pm 25.1 \times 10^3$ cells/ml in Muak Lek to $809 \pm 62.3 \times 10^3$ cells/ml in Wang Muang for medium farms and from $536 \pm 48.5 \times 10^3$ cells/ml in Phattana Nikhom to $749 \pm 40.1 \times 10^3$ cells/ml in Pak Chong for small farms. These results were similar to those reported by Rhone et al (2008a) and Seangjun and Koonawootrittriron (2007). Several researchers (Hansen et al 2002; Othmane et al 2002; Koivula et al 2005) have indicated positive associations between SCC, mastitis and low quality of management. Thus, the high SCC found here is likely be related to low hygienic level in farms (Surawong et al 2004; Ajariyakhajorn et al 2005; Kivaria et al 2006).

Large farms in all locations tended to have higher SCC than smaller size farms (Table 3; Figure 3b). This may be related to lack of training of employees on large farms. Owners of small and medium farms may be more directly involved in their dairies, thus providing a higher quality of management than personnel on large farms. Thus, in order to reduce SCC to acceptable levels (Department of Livestock Development 2003; Thai Agriculture Commodity and Food Standard 2005), large farms would need to increase the level of training of dairy personnel and to improve the management and sanitary conditions of dairy cows.

Individual farm effects

Variation among individual farms and ratios of farm variances to total variances are shown in Table 4.

Table 4. Farm variances and ratio of farm variances to total variances for monthly milk quantity, milk revenue and milk quality

Trait	Farm variances	Ratio of farm variances to total variances
Milk yield per farm, kg ²	1,497,076 ± 70,996 ^a	0.52
Milk yield per cow, kg ²	8,058 ± 421	0.30
Milk revenue per farm, baht ²	202,410,000 ± 9,592,411	0.52
Milk revenue per cow, baht ²	1,082,181 ± 56,551	0.30
Fat, % ²	0.0497 ± 0.00250	0.25
Protein, % ²	0.0128 ± 0.00063	0.25

Lactose, % ²	0.0109 ± 0.00054	0.25
Solids not fat, % ²	0.0281 ± 0.00134	0.29
Total solids, % ²	0.0976 ± 0.00484	0.26
Somatic cell count, ×10 ⁶ cells ² /ml ²	120,054 ± 6,048	0.26

^a Standard error

These ratios indicated that variation associated with differences among individual farms explained from 25% to 52% of the total variation for these traits. Variability among farms could be due to differences in educational background, experience, training, social networks and economic resources of farmers as indicated by Rojanasthien et al (2006) and Rhone et al (2008b). Thus, to improve monthly milk yield and revenues per farm, increasing the level of training, dairying ability and commercial opportunities for farmers should be considered together with improvements in feeding, management, health care and genetics of dairy cattle.

Conclusions

- Monthly milk production per farm and per cow, monthly revenue per farm and per cow, and milk quality traits (fat percentage, lactose percentage, solids not fat percentage, total solids percentage and somatic cell count) of dairy farms were significantly influenced by year-season, farm location-farm size and individual farm effects. Monthly farm values for milk production traits tended to decrease and somatic cell count tended to increase across year-seasons from 2003 to 2007. Milk production per cow was similar across farm location-farm size subclasses. Large farms had higher SCC than small and medium farms. Variation among individual farms accounted for 25% to 52% of the total variability for each trait. Results suggested that, in addition to improvements in dairy cattle management, feeding, health care, and genetics, better training, technical support and commercial opportunities for farmers are needed to foster improvements in dairying production and farm revenues in Central Thailand.

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[Go to top](#)