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Research article

Factors affecting milk composition in dairy farms located in Northern, Thailand

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Abstract

The objectives of this study were to investigate variations in the milk composition and somatic cell count (SCC) from dairy cooperatives in Northern Thailand from January 2017 to December 2021. Milk composition among dairy cooperatives was also compared. The dataset included monthly milk composition (total solid (TS)%, fat%, protein%, lactose%, solid not fat (SNF)% and SCC) data from 15 dairy cooperatives, 2 private organizations, and their milk collection centers (1,800 records) collected in five provinces, including Chiang Mai, Chiang Rai, Lampang, Lamphun, and Phrae. The seasons were cold season (November to February), hot season (March to June), and rainy season (July to October). The dataset was compared among dairy cooperatives using a general linear mixed model. To detect a correlation, spearman correlation coefficients were calculated between SCC and milk composition. Results showed that the season significantly affected milk composition. The hot season appeared as the most critical season for all the parameters examined, showing the significantly lowest values ($P < 0.001$) of TS (12.33±0.3%), fat (3.79±0.27%) and protein (3.02±0.07%) whereas, a significantly highest SCC was obtained in the rainy season (321.21±3.93 x 1,000 cell/ml). Milk collecting centers of dairy cooperatives located in many districts had significantly different milk composition and SCC values. Lactose is the milk component that undergoes the greatest variation in response to the increase in SCC. This study highlighted the variations influencing milk composition and provided information for stakeholders and their roles in the dairy sector at the farm, dairy cooperative, and provincial levels.

Keywords: Dairy cooperative, Milk composition, Northern, Somatic cell counts, Thailand

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INTRODUCTION

The income of dairy farmers in Thailand is not only based on both milk quantity, but also concerned milk quality factors including fat, solid not fat (SNF), somatic cell counts (SCC), and each class has a corresponding rate based on their value (Seangjun and Koonawootrittriron, 2007; Rhone et al., 2008a, b). To encourage dairy farmers to produce high-quality milk, the government established a payment program based on milk quality (PPBMQ), which is currently utilized widely across the country (Dairy Farming Promotion Organization of Thailand, 2015). The payment programs can also be divided into three groups: base, bonus, and penalty. Since fat and SNF are essential nutrients, a higher amount of them is in raw milk, higher pricey. In contrast, milk with high SCC levels is penalized since SCC shortens the shelf life of milk and milk production.

Thai dairy farmers are members of cooperatives and private organizations that manage milk collection centers (Jitmun et al., 2020). These two types of organizations have two main functions: buying milk from dairy producers and serving their members. Identifying key elements influencing milk quality might be beneficial for dairy farmers. Additionally, this knowledge would enable dairy organizations to support their members in a more effective and suitable manner. Several studies have been conducted to evaluate differences in milk composition. It has been discovered that a number of factors are either directly or indirectly related to the variations in milk composition. Some of these factors include genetic factors (Poulsen et al., 2013; Wongpom et al., 2017), seasonal variation, temperature – humidity index (Yang et al., 2013; Bertocchi et al., 2014), feeding system and feed management practices (O'Callaghan et al., 2016; O'Callaghan et al., 2017), lactation stage (Stoop et al., 2009; Soberon et al., 2011), animal health (Moran et al., 2018), herd management and farm (Adler et al., 2013) and other days to day variation.

Although dairy farmers are generally eager to increase milk quality to increase prices, some farmers may not decide to improve their milk quality if given a complex recommendation or must incur additional expenses (Punyapornwithaya et al., 2022). For instance, SCC levels are decreased by rigorous mastitis control programs, however, these initiatives typically involve additional funding or temperature – humidity index (THI) monitoring for SCC and fat (%) using measurement devices (Bertocchi et al., 2014). Identifying the critical variables influencing milk quality in dairy farmers' familiarity patterns would be a better way to manage their limited resources and create possibilities to enhance the effectiveness of their dairy operations. In addition, there are many existing studies investigating factors of milk quality in Chiang Mai province, the largest province in the Northern region (Kongsook and Nantawichain, 2020). Besides, these studies only focus on a small unit such as within their dairy cooperatives. This means that there is an inadequate number of research on the component from broader perceptions and not up to date. Therefore, the objectives of this study were to investigate variations in milk composition and somatic cell count from dairy cooperatives in Northern Thailand from January 2017 to December 2021. Milk composition among dairy cooperatives was also compared.

MATERIALS AND METHODS

Study area and milk quality data

From the Herd Health Unit of the official in charge of livestock region 5, Thailand, a number of monthly milk quality datasets were obtained. 15 dairy cooperatives, 2 private organizations, and their milk collection centers (n = 30) were utilized in five northern Thai provinces, including Chiang Mai, Chiang Rai, Lampang, Lamphun, and Phrae. The list of dairy organizations is illustrated in Table 1. The regional distribution of dairy cooperatives is also shown in Figure 1. These cooperatives meet the criteria of being in business since 2017 and participating in the Department of Livestock Development (DLD) milk quality testing program. The datasets comprised monthly data on the SCC levels and milk composition of raw milk samples obtained from milk collection centers between January 2017 and December 2021(n = 1,800). Fat, protein, lactose, SNF, and total solid (TS) were specifically employed as percentages (%). In contrast, SCC values were multiplied by 1000. For instance, SCC = 320*1000 cells/mL was used to define SCC (de Macedo et al., 2018).

From each milk collecting center, a pooled raw milk sample that represented all of the member dairy farms was obtained each month. Livestock officers sampled the milk and sent to the Veterinary Research and Development Center (Upper Northern Region) Lampang. After that, raw milk samples were transported to a lab within four hours while being kept in cool containers with ice blocks. Then, using Fourier-transformed Infrared Spectroscopy (MilkoScan FT6000, Foss Electric, Hillerød, Denmark), milk samples were examined to determine the composition of the milk, including fat, protein, lactose, SNF, and TS. Consequently, the center used the Fossomatic 5000 (Foss Electric, Hillerd, Denmark) to quantify the SCC (Kampoosiri et al., 2020).

Table 1 List of dairy cooperatives, private organizations and their milk collecting centers in Northern, Thailand

Dairy cooperative	Abbreviation	Dairy cooperative	Abbreviation
Chiang Mai province		**Lamphun province**	
Dairy cooperative 1 (CM1)		**Dairy cooperative 1 (LP1)**	
Milk collecting center in Doi Lo district	DLCM1	Milk collecting center in Muang district	MLP1
Milk collecting center in Sankhampang district	SKCM1	Milk collecting center in Banhong district	BHLP1
Milk collecting center in Sanpahtong district	SPCM1	**Dairy cooperative 2 (LP2)**	
Milk collecting center in Banthi district, Lamphun province	BTCM1	Milk collecting center in Muang district	MLP2
Dairy Company 1 (CM2)		Milk collecting center in Sanpahtong district, Chiang Mai province	SPLP2
Milk collecting center in Sanpahtong district	SPCM2	Dairy Cooperative (LP3) in MaeTha district	MTLP3
Milk collecting center in Maeon district	MOCM2	**Chiang Rai province**	
Milk collecting center in Banthi district	BTCM2	**Dairy Cooperative 1 (CR1)**	
Milk collecting center in Banhong district	BHCM2	Milk collecting center1 in Phan district of Dairy Cooperative 1	P1CR1
Milk collecting center in Maetha district	MTCM2	Milk collecting center2 in Phan district of Dairy Cooperative 1	P2CR1
Dairy Company 2 (CM3)		Milk collecting center in Phaya Mengrai district of Dairy Cooperative 1	MCR1
Milk collecting center in Maetha district	MTCM3	Dairy Cooperative (CR2) in Maelao district	MLCR2
Milk collecting center in Sankhampang district	SKCM3	**Lampang province**	
Milk collecting center in Sanpahtong district	SPCM3	Dairy Cooperative in Hang Chat district	HGLPG
Dairy Cooperative (CM4) in Maeon district	MOCM4	**Phare province**	
Dairy Cooperative (CM5) in Maeon district	MOCM5	Dairy Cooperative in Muang district	MPH
Dairy Cooperative in Mae Wang district	MWCM6		
Dairy Cooperative in Sankhampang district	SKCM7		
Dairy Cooperative 1 in Chaiprakarn district	CPK1CM8		
Dairy Cooperative 2 in Chaiprakarn district	CPK2CM9		
Dairy Cooperative in Sansai district	SSCM10		

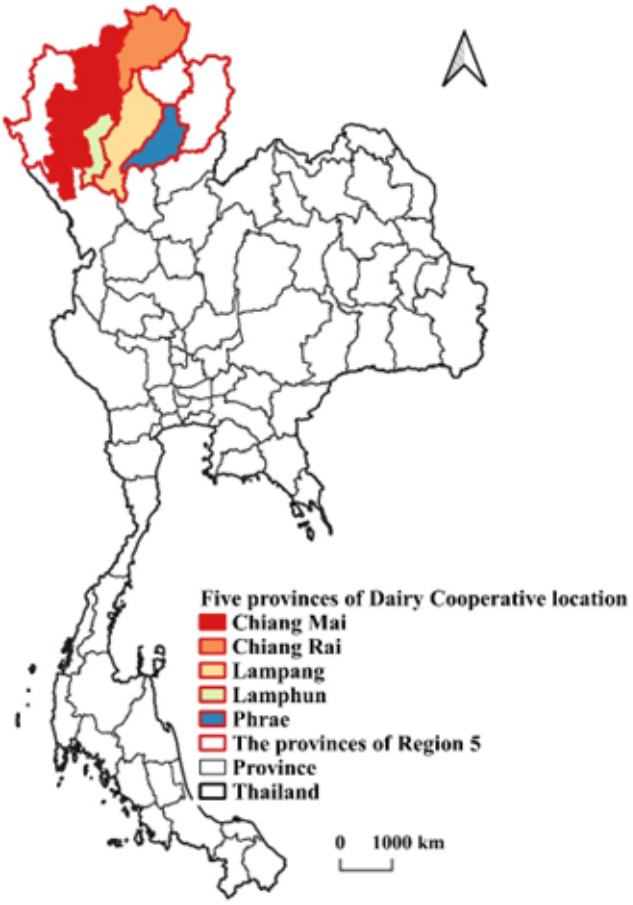

Figure 1 A map shows the provinces of Dairy Cooperative location in Northern Thailand

Seasons in Thailand

There are three seasons in Thailand which can be described in Table 2 (Koonawootrittriron et al., 2009).

Table 2 The climate data

Seasons	Month	Temperature and humidity
Hot	March to June	hot [25 °C to 36 °C] and dry [69% RH, precipitation 187 mm/year]
Rainy	July to October	hot [24 °C to 33 °C] and humid [79% RH, precipitation 903 mm/year]
Cold	November to February	cool [21 °C to 32 °C] and dry [70% RH, precipitation 124 mm/year]

RH= Relative humidity

Statistical analysis

Descriptive characteristics were examined according to year and milk composition. To compare the means of milk datasets among dairy cooperatives and identify seasonal variations, the generalized linear mixed model was used. The random effect model was generated using the nlme function to take the clustering effect of the monthly milk datasets into account. Milk datasets were clustered within dairy cooperative (Pinheiro et al., 2020) in R statistic software (R core team, 2022). The model is written as,

$$y_{ij} = \beta_0 + \beta_i x_i + b_j + \varepsilon_{ij}$$

Where y_{ij} represent the milk datasets of the i^{th} dairy cooperative from j^{th} clusters. $\beta_0$is the intercept. $\beta_i x_i$ is the fixed-effects regression coefficient. The random effect b_j is assumed to vary independently across clusters with $b_j \sim N(0, \sigma_2^2)$. The errors, ε_{ij} are assumed to vary independently across clusters with $\varepsilon_{ij} \sim N(0, \sigma_\varepsilon^2)$. For Post Hoc multiple comparisons, Tukey's method was applied. The level of significance for all statistical analysis were set at 0.05.

To detect a correlation, spearman correlation coefficients were calculated among variables including the SCC, fat%, protein%, lactose%, TS%, and SNF%.

RESULTS

A total of 1,800 records were collected and analyzed to obtain the descriptive statistics results shown in Table 3.

Table 3 The descriptive statistics of milk datasets from 2017 to 2021 (n=1,800)

Milk datasets	Year	Mean	Standard deviation	Range
Total solid (%)	2017	12.29	0.37	10.89 - 16.08
	2018	12.45	0.27	11.21 - 14.91
	2019	12.38	0.35	10.56 - 15.69
	2020	12.40	0.25	11.07 - 14.25
	2021	12.45	0.28	11.31 - 14.63
Fat (%)	2017	3.72	0.33	2.74 - 7.65
	2018	3.85	0.24	2.86 - 6.47
	2019	3.85	0.23	2.11 - 4.60
	2020	3.90	0.23	2.43 - 5.83
	2021	3.96	0.26	2.94 - 6.59
Protein (%)	2017	2.98	0.08	2.50 - 3.38
	2018	3.02	0.09	2.71 - 3.35
	2019	3.06	0.09	2.60 - 3.34
	2020	3.05	0.06	2.89 - 3.26
	2021	3.04	0.06	2.74 - 3.25
Lactose (%)	2017	4.84	0.12	4.03 - 5.23
	2018	4.76	0.06	4.59 - 5.00
	2019	4.71	0.05	4.34 - 4.99
	2020	4.71	0.04	4.60 - 4.96
	2021	4.71	0.04	4.54 - 4.85
Solid not fat (%)	2017	8.58	0.14	7.38 - 9.39
	2018	8.61	0.11	8.23 - 9.00
	2019	8.53	0.14	7.30 - 9.00
	2020	8.49	0.11	8.15 - 9.07
	2021	8.47	0.12	7.79 - 8.84
Somatic Cell Count (x 1,000 cell/ml)	2017	317.12	119.31	100 - 1,046.57
	2018	288.19	85.26	80.00 - 744.00
	2019	297.26	85.04	13.00 - 596.00
	2020	304.60	100.38	13.00 - 790.00
	2021	308.39	91.88	111.00 - 588.00

Accordingly, the season showed a significant effect on milk composition (fat%, protein%, lactose%, SNF%, TS% and SCC). The hot season appeared as the most critical season (Table 4) for all the parameters examined, showing the lowest values ($P < 0.001$) of fat (3.79 ± 0.27%), protein (3.02 ± 0.07%) TS (12.33 ± 0.13%) and SCC (290.83 ± 99.49 x 1,000 cell/ml). On the other hand, a significantly highest SCC ($P < 0.05$) was obtained in rainy (321.21 ± 96.43 x 1,000 cell/ml).

Table 4 Least squares means and standard deviation of milk composition between 2017 to 2021

Seasons	Total Solid (%)	Fat (%)	Protein (%)	Lactose (%)	Solid Not Fat (%)	Somatic Cell Count (X1,000cell/ml)
Hot (n=600)	12.33 ± 0.3[a]	3.79 ± 0.27[a]	3.02 ± 0.07[a]	4.77 ± 0.09[a]	8.55 ± 0.13[a]	290.83 ± 99.49[a]
Rainy (n=600)	12.42 ± 0.26[b]	3.9 ± 0.22[b]	3.05 ± 0.07[b]	4.72 ± 0.08[b]	8.51 ± 0.13[b]	321.21 ± 96.43[b]
Cold (n=600)	12.42 ± 0.3[b]	3.88 ± 0.3[b]	3.03 ± 0.09[c]	4.75 ± 0.06[c]	8.54 ± 0.13[a]	297.29 ± 94.34[c]

[a,b,c] Means with different superscript are significantly different ($P < 0.05$).

The fluctuations in the milk composition and SCC parts over the investigation are depicted in Figure 2 (Supplementary table 1). Milk collecting centers of dairy cooperatives which are located in many districts had significantly different milk composition and SCC values. Along with mean and standard deviation, the milk collection center in Muang district of Dairy Cooperative 2, Lamphun province (MLP2) reported the significantly lowest fat (3.64 ± 0.25%) and TS (12.17 ± 0.29%). On the other hand, the milk collection center in Sankhampang district of the Dairy Cooperative 1, Chiang Mai province (SKCM1) revealed the significantly highest fat (4.04 ± 0.2%) and TS (12.63 ± 0.22%). These results are shown Figures 2A and 2E. The milk collecting center in Banhong district of Dairy Cooperative 1, Lamphun province (BHLP2) reported the significantly lowest lactose (4.71 ± 0.06%) and SNF (8.42 ± 0.0 %) (Figure 2C and 2D). In addition, there was a significant difference in protein (2.94 ± 0.09%) the Milk collecting center in Phan district of Dairy Cooperative1, Chiang Rai province (PCR1) (Figure 2B). Figure 2F illustrated that Dairy Cooperative 1 in Chaiprakarn district (CPK1CM8), Chiang Mai province has the significantly lowest SCC (176.58 ± 32.7%), while, The Dairy Cooperative1's Milk Collecting Center in Sanpahtong district (CMSP) has the noticeably highest SCC (364.90 ± 120.18%). When compared to the other dairy cooperatives, the protein (3.12 ± 0.01%), lactose (4.81 ± 0.08%), and SNF (8.75 ± 0.18%) of milk collection center in Phaya Mengrai district of the Dairy Cooperative (MRCR1), Chiang Rai province computed for the considerably highest values ($P < 0.05$).

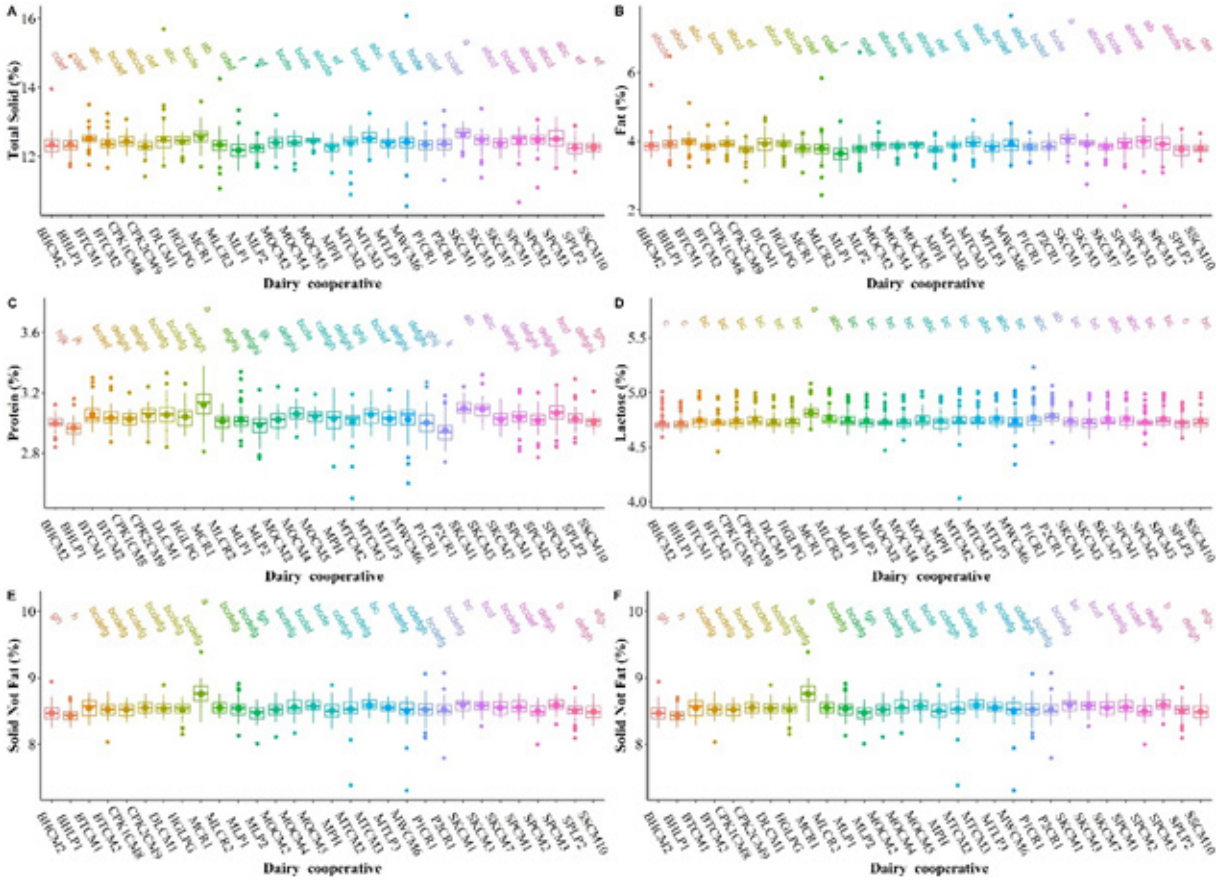

Figure 1 Dot plot indicates Least squares means ± standard d, as well as boxplot, boxplot the indicates median and range of milk composition (2017-2021) for dairy cooperatives in Northern, Thailand. a-k denote means with different superscript are significantly different ($P < 0.05$). A: Total Solid (%) B: Fat (%) C: Protein (%) D: Lactose (%) E: Solid Not Fat (%) F: Somatic Cell Count (x 1,000 cell/ml)

Supplementary table 1 Least squares mean ± standard deviation of milk composition (2017-2021) for dairy cooperatives in Northern, Thailand (n=1800).

Dairy cooperative	Total Solid (%)		Fat (%)		Protein (%)		Lactose (%)		Solid Not Fat (%)		Somatic Cell Count (X1,000cell/ml)	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
BHLP1	12.34	0.40	3.92	0.39	2.97	0.06	4.72	0.07	8.43	0.10	349.68	94.42
DLCM1	12.49	0.55	3.91	0.32	3.05	0.10	4.73	0.08	8.54	0.10	322.45	119.06
BTCM1	12.52	0.24	3.96	0.24	3.06	0.08	4.74	0.08	8.55	0.13	346.39	71.58
SKCM1	12.64	0.22	4.05	0.21	3.10	0.05	4.74	0.07	8.59	0.10	345.11	74.35
SPCM1	12.44	0.33	3.89	0.33	3.04	0.07	4.76	0.08	8.56	0.10	364.91	120.18
HGLPG	12.42	0.22	3.90	0.20	3.04	0.07	4.74	0.08	8.52	0.12	269.88	44.56
CPK1CM8	12.44	0.20	3.92	0.18	3.03	0.05	4.74	0.09	8.52	0.10	176.58	32.70
P2CR1	12.36	0.28	3.85	0.17	2.95	0.09	4.78	0.08	8.52	0.16	228.35	111.45
P1CR1	12.35	0.23	3.82	0.17	3.00	0.09	4.77	0.11	8.52	0.17	262.91	109.96
MCR1	12.56	0.29	3.79	0.20	3.12	0.12	4.81	0.08	8.76	0.18	310.87	131.22
MOCM5	12.40	0.22	3.85	0.15	3.06	0.06	4.74	0.08	8.56	0.14	355.21	72.74
BHCM2	12.34	0.29	3.87	0.28	3.00	0.06	4.72	0.08	8.47	0.13	307.10	87.29
BTCM2	12.38	0.23	3.84	0.19	3.03	0.07	4.73	0.08	8.52	0.12	288.71	59.51
MOCM2	12.39	0.23	3.88	0.18	3.02	0.06	4.73	0.07	8.52	0.12	320.93	66.98
MTCM2	12.38	0.36	3.86	0.25	3.01	0.10	4.75	0.13	8.53	0.20	299.60	79.85
SPCM2	12.48	0.28	3.99	0.25	3.02	0.07	4.73	0.07	8.50	0.12	349.99	118.31
MLP1	12.26	0.37	3.79	0.41	2.99	0.08	4.74	0.08	8.47	0.12	328.12	67.81
MLP2	12.18	0.29	3.64	0.25	3.02	0.09	4.75	0.08	8.53	0.14	292.90	98.51
SPLP2	12.25	0.25	3.75	0.23	3.03	0.07	4.72	0.07	8.50	0.13	324.82	67.14
MTLP3	12.37	0.20	3.82	0.20	3.03	0.06	4.76	0.07	8.55	0.09	313.97	45.12
SSCM10	12.26	0.19	3.78	0.16	3.01	0.04	4.74	0.08	8.49	0.11	237.63	51.53
MLCR2	12.33	0.39	3.79	0.40	3.01	0.05	4.77	0.09	8.55	0.10	273.22	105.18
MOCM4	12.44	0.13	3.87	0.12	3.04	0.05	4.76	0.08	8.58	0.10	358.89	59.44
MWCM6	12.42	0.59	3.92	0.55	3.02	0.10	4.74	0.11	8.50	0.20	264.36	68.29
MPH	12.26	0.23	3.75	0.23	3.03	0.09	4.74	0.08	8.50	0.13	332.57	175.47
SKCM7	12.37	0.19	3.82	0.16	3.02	0.05	4.76	0.08	8.55	0.10	311.22	52.77
CPK2CM9	12.28	0.21	3.73	0.20	3.05	0.07	4.75	0.08	8.55	0.09	233.36	96.09
MTCM3	12.51	0.27	3.93	0.26	3.06	0.07	4.76	0.08	8.59	0.09	307.53	57.97
SKCM3	12.47	0.28	3.90	0.27	3.09	0.07	4.73	0.08	8.58	0.10	300.16	72.95
SPCM3	12.50	0.31	3.91	0.28	3.07	0.08	4.76	0.08	8.59	0.10	315.97	63.53

sd= standard deviation

The study also found that seasonal variations affected milk composition and dairy cooperative. Changes of milk composition and SCC in seasonal variation and Dairy Cooperatives are reported in Figure 3. The milk collection center in Sankhampang district of the Dairy Cooperative 1, Chiang Mai province (SKCM1) had the considerably highest fat and TS for the rainy season, whereas the milk collection center in Muang district of Dairy Cooperative 2, Lamphun province (MLP2) had the significantly lowest fat and TS for all seasons. milk collection center in Phaya Mengrai district of the Dairy Cooperative (MRCR1) had the significantly highest of protein and SNF for cold season and the significantly highest lactose in the hot season. Milk collecting center1 in Phan district of Dairy Cooperative 1 had the significantly lowest protein during

hot and cold seasons. There were 4 dairy cooperatives with the significantly lowest lactose, including milk collecting center in Sanpahtong district of Dairy Company 1 (CM2), milk collecting center in Banhong district of Dairy Cooperative 1, Lamphun province, Dairy Cooperative in Sansai district and Milk collecting center in Sankhamare pang district of Dairy Company2. Results illustrated in Figure 3B-3D. According to SCC results, The Milk collecting Center in Sanpatong District of the Dairy Cooperative 1, Chiang Mai province had the significantly highest value of SCC, whereas the dairy Cooperative 1 in Chaiprakarn district had the significantly lowest value of SCC during the rainy season.

Somatic cell counts had negative correlation with lactose ($P < 0.001$) and SNF ($P < 0.01$) and positive correlation with TS, fat and protein ($P < 0.001$). The results of the correlation are shown in Table 5.

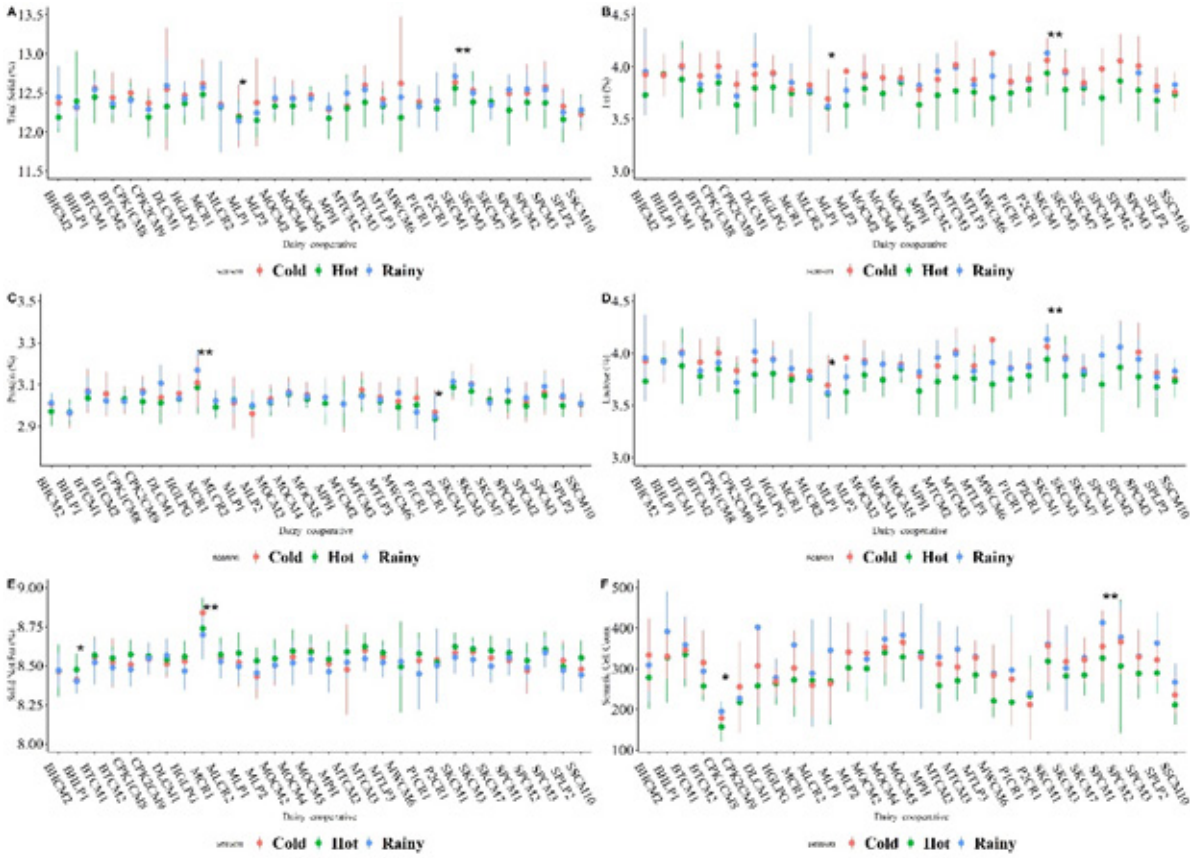

Figure 2 Dot plot indicates Least squares means ± standard d, as well as boxplot, boxplot the indicates median and range of milk composition (2017-2021) for dairy cooperatives in Northern, Thailand. a-k denote means with different superscript are significantly different ($P < 0.05$). A: Total Solid (%) B: Fat (%) C: Protein (%) D: Lactose (%) E: Solid Not Fat (%) F: Somatic Cell Count (x 1,000 cell/ml)

Table 5 Correlation of somatic cell count with milk composition.

Parameter	Total Solid (%)	Fat (%)	Protein (%)	Lactose (%)	Solid Not Fat (%)
Somatic cell count (x1,000cell/ml)	0.12***	0.16***	0.12***	-0.18***	-0.05*

*($P < 0.05$), ***($P < 0.001$)

DISCUSSION

Seasonal variations change affected milk composition and related dairy cooperatives have been highlighted. The present study showed the averages fat%, protein%, TS% and SCC in hot season were significantly lowest ($P < 0.05$), while lactose% was significantly highest compared to rainy and cold seasons. Mostly the main milk composition in some studies where similar results have been found (Yeamkong et al., 2010; Hammami et al., 2013; Kongsook and Nantawichain, 2020; Thammahakin et al., 2020). Those authors explained that the change of main milk components in different seasons is caused by several reasons. First, the effect of heat stress is a decline in feed intake, influencing the metabolism of the animal, milk production and milk composition. (Suadsong et al.,2008; Bertocchi et al., 2014; Sae-tiao et al, 2015). Previous studies indicated most dairy cows in the Thai dairy cattle population (91%) are crossbreds and have a Holstein fraction higher than 87.5%. High temperatures and humidity in different regions of Thailand fall within the range of stressful temperature-humidity index (THI) values for dairy cattle. THI has been used to classify levels of comfort and stress zones of animals. THI was higher than 72 units as hot season caused stressful conditions for dairy cows that affected their feed intake and interfered with fat and protein synthesis. Second, an increase in protein but a decrease in lactose % was observed in the water content in milk. Lactose level is indirectly related to protein level because lactose is the major factor responsible for level of water secretion into milk which determines the fat and protein content of milk (Miglior et al., 2006). Lastly, the nutritional fluctuations of diet during different seasons are related to changing availability and quality of pasture (Yang et al., 2013). For example, the main feed resources are green forage from the farm pasture, public areas and roadside pastures, which are abundant only in the rainy season. The farmers are forced to use crop by-products as roughage in the hot and cold seasons, especially rice straw. Additionally, the cost of these food ingredients is lower than at other periods, when feed production grows slowly and prices are higher. As a result, farmers began substituting low-quality feed components with nutritive value is limited due to their low digestibility, low nitrogen and low mineral and vitamin content (Sruamsiri, 2007).

Milk somatic cells are a mixture of milk-producing cells and immune cells. These cells are secreted in milk during the normal course of milking and are used as an index for estimating mammary health and milk quality of dairy cattle (Alhussien et al., 2018). It is well known that high values of SCC in bulk milk are closely related to high individual SCC, indicating a high prevalence of subclinical mastitis. Thus, SCC has been used as an indicator of mastitis control program (Waage et al., 1998). Our results reported the significant increase in SCC during the rainy. The reason probably due to the high risk of the exposing teats to the muddy floor resulting in increased subclinical mastitis and SCC in bulk tank milk during rainy season (Biffa et al., 2005). In Thailand, farms having mud in the barns had an average of SCC more than dried barns (Suriyasathaporn et al., 2002).

In the present study, a significant negative correlation was found between lactose and SNF in response to increasing SCC, whereas the fat, protein and TS % show a significant positive correlation. The results obtained in the study were similar to other observations in both farm and cooperative levels

(Suriyasathaporn et al., 2002; Suriyasathaporn et al., 2010; Cinar et al., 2015; Jatawa et al., 2015). Studies concluded that an increase in SCC can perform as an indicator of the presence of inflammatory alterations in the mammary gland. The permeability changes related to inflammatory reactions in milk secretory cells might cause changes in milk components such as protein, fat and lactose (Korhonen and Kaartinen, 1995). Lactose is the component of milk that undergoes the greatest variation in response to the increase in SCC. A previous study found that the mammary epithelial cells' cellular junctions change, allowing a larger passage of salts from the blood into the milk (Stelwagen et al., 2000). All tissue secretion is compromised, which also affects the rate of lactose synthesis, which always occurs at a slower rate in milk from mastitis. The arrival of glucose at the gland is also complicated by the glandular edema. This indicates that monitoring the lactose% in milk, along with the SCC, could be the predictor in udder health control program (Leitner et al., 2011).

For purpose of this study, we aimed to provide raw milk composition and SCC information to dairy cooperatives, which is critical for managing milk quality in the region. Therefore, the analysis compared the milk composition and SCC of dairy cooperatives to all dairy cooperatives operating from 2017 to 2022. The Milk Collecting Center in Muang District, Lamphun province had the significantly lowest fat and TS % for all three seasons. The milk collecting center in Banhong district, Lamphun province had the significantly lowest lactose and SNF % in the rainy season. The Milk Collecting Center in Sanpatong District, Chiang Mai province had the considerably highest value of SCC. This finding provided evidence that dairy farmers from these dairy cooperatives have a high chance to receive a price that is lower than the base price on a regular basis of a payment program based on milk quality or PPBMQ. Moreover, it is important to point out that milk collecting centers which located in many districts had significantly different milk composition and SCC values. This result challenges dairy cooperatives and companies broad to establish performance standards for each milk collecting center. Particularly noteworthy is the unique pattern of a private company in Chiang Mai in which dairy farms sell bulk milk to the company individually via the dairy cooperative system. (Punyapornwithaya et al., 2020). Farmers' participation, training, and education were recommended to improve this performance.

The findings of this study can be used as evidence to help dairy farmers understand the seasonality that affects the raw milk quality and to set guidelines for resolving issues with raw milk composition at the farm level. Planning is necessary for the hot and cold seasons to address the quantity of low-quality feeding, and feed supplies are prepared in feed supply. During the rainy season, farm management practices including increasing ventilation, reducing the humidity, and maintaining a drier barn can help decrease the seasonal effect that affects subclinical mastitis and SCC. At the dairy cooperative level, we suggested that authorities and stakeholders collaborate to assist such dairy farmers from different milk collecting center locations in improving or enhancing milk quality while maintaining profitability through the provision of technical, financial, and other support. A mastitis control program policy must be established in each dairy cooperative to organize each milk collecting center. Monthly SCC and lactose control in dairy farms is one of the most effective methods for monitoring and evaluating changes in milk production and milk quality. At the province level, establishing rules, regulations, and strict

guidelines for milk quality control as well as promoting the use of innovations and contemporary technology to improve milk quality are being done by the regional and provincial government authorities.

It is worth noting that this study examined key variables influencing milk quality in dairy farmers' familiarity patterns. It is worth noting that this study examined key variables influencing milk quality in dairy farmers' familiarity patterns. Furthermore, the investigation was carried out at the dairy cooperative and provincial levels, providing information for stakeholders and their roles in the dairy sector. To enhance the study, milk production analysis and survey of decision making practices, as well as the participation of dairy farmers in milk quality development should be studied in the future and further dairy production research in Thailand.

CONCLUSIONS

This study highlighted the factors that influence milk composition and provided information for stakeholders and their roles in the dairy sector. This will help dairy farmers resolve milk composition issues in an accessible manner. Meanwhile, authorities and dairy stakeholders should use this information to strengthen their support for such dairy farmers in order to improve milk quality and increase their benefits. Notably, other factors influencing milk composition, such as milk production and dairy farmer participation in milk quality development should be investigated in the future study.

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AUTHOR CONTRIBUTIONS

SK: Methodology, formal analysis, data curation, writing - original draft preparation, writing - review and editing, and visualization.
SR: Conceptualization, methodology, validation, formal analysis, visualization, supervision, and project administration.
WS, CJS, PS: Software, formal analysis, and visualization.
TP, PR, AS, RA: Investigation, resources, and visualization.
CC, VY, AP, NC: Investigation and resources.
SS, CL: writing - review and editing and visualization
CS, KL: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing - original draft preparation, writing - review and editing, visualization and supervision. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have on conflict of interests.

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