Research Article

Subclinical Mastitis Affects Milk Yield and Quality in Smallholder Dairy Cow Farms in the Highlands and Southern Vietnam

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Abstract | The objective of the study was to investigate milk yield and quality in small-scale dairy cow operations and to assess milk production affected by subclinical mastitis. The study was conducted in the highlands and southern Vietnam, including Lam Dong, Long An, Tien Giang province, and Ho Chi Minh City. A total of 1,347 small dairy farms were surveyed over 12 months in 2022. The average number of dairy cows per smallholder farm was approximately 9 cows with 11.52 ± 4.56 kg/cow/day. Milk yield was measured for the total number of dairy cows per smallholder, and 10 milk quality parameters included somatic cell count (SCC) and others (total solid, fat, solid-non-fat, crude protein, pH, free fatty acids, lactose, temperature, true protein), and examined by Foss–Milkoscan machines in dairy centers. SCC was classified into 5 levels (<100, 100-<200, 200-<400, 400- <1,000, and ≥1,000 10^3 cell/ml milk). The milk yield was highest at 16.76 ± 7.86 kg/cow/day, and SCC was lowest at 356.54 ± 191.43 (10^3 cell/ml milk) in Lam Dong province (the highlands region), and different from that of other provinces in southern Vietnam (10.92 ± 3.50 kg/cow/day and 360.85 ± 187.24x10^3 cell/ml milk in Long An; 11.56 ± 3.00 kg/cow/day and 399.82 ± 175.35x10^3 cell/ml milk in Tien Giang; and 10.90 ± 3.73 kg/cow/day and 465.46 ± 222.68x10^3 cell/ml milk in Ho Chi Minh City) (P < 0.05). The results indicated that seasonality affected milk production in all provinces for months and highlighted a negative relationship between milk production, milk quality, and SCC levels in smallholder dairy farms in the highlands and the south of Vietnam.

Keywords | Dairy cows, Milk yield and quality, Smallholders, Subclinical mastitis, Vietnam

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INTRODUCTION

Dairy cow breeding has recently developed in Vietnam (Vu *et al.*, 2016; Nguyen *et al.*, 2023a). The Ministry of Agriculture and Rural Development (2022) said Vietnam has more than 28,000 farms and smallholders with a total herd of nearly 375,000 dairy cows, has achieved fresh milk production reaching more than 1.2 million tons per year, and provides more than 42% of milk consumption of citizens. In the highlands and southern Vietnam, large-scale dairies and small-holder farms are in Lam Dong, Long An, Tien Giang province, and Ho Chi Minh City

(Vu *et al*., 2016; Nguyen *et al*., 2023a, b). Vietnam's dairy processors have also established milk collection centers in these regions to purchase milk from farms and smallholders. The standards for evaluating milk quality are total solids, milk fat, solids-not-fat (SNF), lactose, somatic cell count, and milk is also cultured to look for pathogenic bacteria that guarantee the food safety of milk for customers (Ostensson *et al*., 2013; Vu *et al*., 2016). In high-producing dairy cows in Vietnam, subclinical mastitis poses a high risk of developing clinical mastitis, which not only reduces milk production and quality but also causes economic losses due to treatment costs and culling cows (Nielsen, 2009; Ibrahim, 2017; Goncalves *et al*., 2018). Ostensson *et al*. (2013) reported that the rate of subclinical mastitis was 63.2% at the quarter level and 88.6% at the cow level in southern Vietnam; subclinical mastitis was characterized by more than 400,000 somatic cells per milliliter of milk. Additionally, cows with subclinical mastitis have a high potential risk of developing clinical mastitis (Fox, 2009; Cardozo *et al*., 2015; Argaw, 2016; Khasanah *et al*., 2021). The economic benefit of smallholder farms depends on milk yield and quality of dairy cows in Vietnam. Therefore, this study aimed to investigate milk yield and quality in small-scale dairy farms in the highlands and southern Vietnam and to evaluate subclinical mastitis that affected milk production.

MATERIALS AND METHODS

Smallholder dairy farms and sample collection

A total of 1,347 smallholder dairy cow farms were surveyed in 4 provinces, including Lam Dong in the Highlands and Long An, Tien Giang, and Ho Chi Minh City in southern Vietnam, for 12 months in 2022. In southern Vietnam, the weather of Long An, Tien Giang, and Ho Chi Minh City had 2 seasons. During the dry season, from November to April, the average temperatures were 26°C - 34°C, and the average humidity was about 62%; the rainy season, from May to October, was 22°C-31°C and 83% humidity. Meanwhile, Lam Dong province was in a highland area, where the weather was cooler during the year, with 18-25°C and 85-87% humidity (VietNam Weather Forecast, 2022).

Holstein and Sind crossbred dairy cows were included in at least 3 cows per smallholder. Milk samples were manually collected from all the lactating dairy cows regardless of parity or days in milk, and there was no clinical mastitis at the milking time in smallholders as composite samples. Dairy cows were kept in the free-stall barns with a diet of total mixed ration silage, elephant grass, or by products.

Farmers collected the milk from dairy cows twice a day, from 4 a.m. to 8 a.m. and from 2 a.m. to 4 p.m., and sold it to the dairy company's collection centers after milking. The parameters were analyzed in the milk company's laboratories. They managed all information about the smallholders' dairy cows, including the identification of the smallholders, the number of cows/smallholders, as well as the results in milk yield and quality. Milk yield was measured for the total number of dairy cows per smallholder from January to December 2022. Milk quality was measured using 10 parameters, including somatic cell count (SCC) and others (total solid, fat, solid-non-fat, crude protein, pH, free fatty acids, lactose, temperature, true protein), examined by Foss–Milkoscan machines in milk centers. The SCC is classified into 5 levels (< 100,000, 100,000 - < 200,000, 200,000 - < 400,000, 400,000 - < 1,000,000, and ≥ 1,000,000 cell/ml of milk). Subclinical mastitis is characterized by more than 400,000 somatic cells per milliliter of milk (Olde *et al*., 2007; Ostensson *et al*., 2013; Looper, 2012; Sharma *et al*., 2011).

The Animal Care and Use Committee of Nong Lam University, Ho Chi Minh City, Vietnam, approved the procedures and protocols for the dairy cow investigation.

Data analysis

Milk production and quality data were subjected to a one-way analysis of variance to examine differences between provinces, zones, milk quality parameters, months, and SCC levels using the test of the chi square of Minitab software (version 17.0).

RESULTS AND DISCUSSION

Milk yield of dairy cows in smallholder farms in the highlands and southern Vietnam

A total of 1,347 small dairy farms across 4 provinces were enrolled in the study. Milk yield and quality were studied in Lam Dong province (highland region) and Long An, Tien Giang, Ho Chi Minh City (southern Vietnam). The average milk yield and standard deviation are presented in Table 1. The average number of cows in Tien Giang was highest at 10.91±9.85 cows/smallholder, followed by Lam Dong at 9.50±5.86 cows/smallholder, and Long An and Ho Chi Minh City at 8.74±5.01 and 8.84±7.40 cows/smallholder (respectively). The overall average number of dairy cows on smallholder farms in this study was approximately 9 cows/smallholder.

The overall average milk yield/cow/day was 11.52±4.56 kg/cow/day. Milk yield was highest at 16.76±7.86 kg/cow/day in Lam Dong province in the highland region, which was significantly higher than other southern provinces (Table 1 and Figure 1, P < 0.05). Milk yield was the same in Long An and Ho Chi Minh City, at 10.90 kg/cow/day. In contrast, milk production in Tien Giang was 11.56±3.00 kg/cow/day. The highland region experienced cooler

Table 1: The monthly and annual milk yield of dairy cow smallholder farms, average and standard deviation.

	Lam Dong	Long An	Tien Giang	Ho Chi Minh City	Average	P value
Total smallholder (n=1,347)	132	385	91	739	336.75	
Cows/smallholder ($\bar{X}$±SD)	9.50±5.86^{a}	8.74±5.01^{b}	10.91±9.85^{c}	8.84±7.40^{b}	9.02±6.89	0.000
Milk yield/smallholder/month (kg)	4,752.7^{a}	2,936.0^{b}	3,819.0^{c}	2,926.2^{b}	3,168.3	0.000
Milk yield/smallholder/day (kg)	156.33^{a}	96.59^{b}	125.61^{c}	96.30^{b}	104.24	0.000
Milk yield/cow/day (kg)	16.76±7.86^{a}	10.92±3.50^{b}	11.56±3.00^{c}	10.90±3.73^{b}	11.52±4.56	0.000
January (kg/cow/day)	17.09±4.03	12.06±3.24	12.26±2.73	12.45±3.44	12.77±3.69^{a}	0.000
February (kg/cow/day)	17.22±4.11	12.02±3.20	12.32±2.65	12.29±3.49	12.70±3.74^{a}	
March (kg/cow/day)	17.50±3.99	11.70±3.20	12.57±2.82	11.79±3.50	12.38±3.82^{a}	
April (kg/cow/day)	17.31±3.86	11.42±3.20	12.35±2.82	11.21±3.43	11.95±3.82^{ab}	
May (kg/cow/day)	16.97±3.74	10.95±3.03	11.84±3.07	10.61±3.47	11.41±3.82^{bc}	
June (kg/cow/day)	19.90±20.59	10.44±3.71	10.88±3.28	10.77±3.47	11.57±8.05^{ab}	
July (kg/cow/day)	16.97±10.29	10.30±3.26	10.77±2.88	9.98±3.55	10.81±5.00^{cd}	
August (kg/cow/day)	15.90±3.69	10.06±3.48	10.70±2.73	9.87±3.56	10.57±3.92^{d}	
September (kg/cow/day)	15.84±3.60	9.84±3.36	10.67±2.97	9.98±3.72	10.56±3.97^{d}	
October (kg/cow/day)	15.35±3.57	10.17±3.46	10.91±3.08	10.21±3.66	10.75±3.87^{d}	
November (kg/cow/day)	15.67±8.05	10.70±3.45	11.24±2.82	10.69±3.88	11.22±4.55^{cd}	
December (kg/cow/day)	15.45±4.11	11.38±4.28	12.15±3.25	10.93±3.19	11.58±3.86^{bc}	

Significantly different values are denoted with subscripts a, b, and c (P<0.05).

weather with lower temperatures and higher humidity, providing better conditions for milk production from dairy cows. Vo (2011) presented 16 kg/cow/day of Holstein Friesian (HF) and Sind crossbreeding among smallholder dairy farms in southern Vietnam, and Tran *et al.* (2022) conducted a study in 2 dairy cow farms in Ho Chi Minh City, which showed a milk yield of 13.5-27.6 kg/cow/day for 27 to 37 days in milk in their experiments. Milk yield in the highland zone was 24.26 kg/cow/day based on 14,988 data collected from October 2021 to March 2022 from dairy cow farms in Vietnam (Nguyen *et al.*, 2023b).

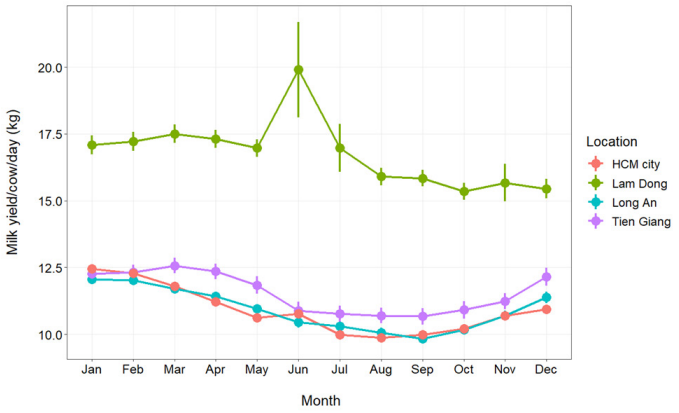

Figure 1: Milk yield of dairy cows in smallholder farms during the months of the year. average and standard error.

Seasonality affected milk production in all provinces during several months of the year (P < 0.05). For the southern regions, the highest milk production occurred from January to March and decreased from April to October. Milk production then increased again in November and December. Milk production from smallholders' dairy cows indicated that it remained stable for several months, including January to March, April to June, July to October, and November to December (Figure 1). However, the highland province (Lam Dong) was different with a peak in May and June. Although milk production data was collected for all milking dairy cows per smallholders, without distinguishing parity or day in milk or breed, farmers followed the breeding season with thermal stimulation and artificial insemination. The Smallholder Dairy Fertility Plan has helped farmers benefit from better calf care programs and good weather conditions for parturition. Nguyen *et al.* (2023b) reported that milk production was highest in December and January (25 kg/day/cow) and decreased in February and March (23.6 kg/day/cow) in mountainous areas of Vietnam. Nguyen *et al.* (2020) indicated the seasonal variation influenced milk yield and milk composition between summer and winter in dairy cow farms, especially milk SCC and protein.

The quality of milk from dairy cows in smallholder farms in the highlands and southern Vietnam

There were 10 milk quality parameters in 4 provinces shown in Table 2. The results showed that milk yield in Ho Chi Minh City was the lowest (10.90±3.73 kg/cow/day) but the highest somatic cell count (SCC) at 465.46 ± 222.68

Table 2: The milk quality of dairy cows in smallholder farms in 4 provinces, average and standard deviation.

No	Parameters	Lam Dong	Long An	Tien Giang	Ho Chi Minh city	Average	P-value
1	SCC (cell/ml)	356.54±191.43[a]	360.85±187.24[a]	399.82±175.35[b]	465.46±222.68[c]	420.47±213.17	0.000
2	TS (%)	12.84±0.38[a]	13.27±0.54[b]	13.15±0.45[c]	12.98±0.51[d]	13.06± 0.53	0.000
3	Fat (%)	4.19±0.38[a]	4.53±0.46[b]	4.44±0.41[c]	4.27±0.45[d]	4.35±0.46	0.000
4	SNF (%)	8.72±0.16[a]	8.81±0.21[b]	8.78±0.18[c]	8.78±0.21[c]	8.79±0.21	0.000
5	Cru.Prot (%)	3.20±0.15[a]	3.29±0.21[b]	3.27±0.17[c]	3.30±0.21[b]	3.29±0.21	0.000
6	pH	6.57±0.07[a]	6.64±0.05[b]	6.62±0.05[c]	6.64±0.05[d]	6.63±0.06	0.000
7	FFA (%)	5.33±0.80[a]	5.08 ±.0.74[b]	5.06±0.62[b]	5.41±0.91[c]	5.29±0.85	0.000
8	Lactose (%)	4.89±0.10[a]	4.92±0.11[b]	4.90±0.12[c]	4.87±0.13[d]	4.89±0.12	0.000
9	Temp (^{0}C)	38.69±0.90[a]	39.15±0.82[b]	39.31±0.91[c]	39.14±0.80[b]	39.11±0.84	0.000
10	Tru.Prot (%)	3.03±0.15[a]	3.13±0.22[b]	3.11±0.17[c]	3.14±0.22[b]	3.12±0.21	0.000

Significantly different values are denoted with subscripts a, b, and c (P<0.05)

(10^3 cells/ml of milk). Meanwhile, milk yield in Lam Dong was the highest (16.76±7.86 kg/cow/day), and SCC was the lowest at 356.54±191.43 (10^3 cells/ml of milk). Nasr and El-Tarabany (2017) recorded that SCC levels could increase due to high environmental humidity and temperature. This could be explained by the differences in SCC between provinces in this study (P < 0.01); Lam Dong province experienced cooler weather in mountainous areas than in southern provinces. Long An and Tien Giang province ranged between 360.85 and 399.82 (10^3 cells/ml of milk). Milk quality was mainly assessed by SCC, a significant indicator of mammary gland health (Li *et al.*, 2014). Besides SCC, the important components of milk were total solids (TS), fat, solid-non-fat (SNF), protein, and lactose, which determined milk quality and the price of milk (Midau *et al.*, 2010; Nefasa *et al.*, 2022). The average TS was 13.06±0 .53%, highest in Long An and Tien Giang at 13.27±0.54 and 13.15±0.45%, respectively. Fat was also highest in Long An and Tien Giang, with 4.53 ± 0.46, and 4.44±0.41%. The mean of SNF was 8.79±0.21%, and that of lactose was 4.89±0.12%. In general, Long An province had lower SCC and higher milk quality than other provinces. Other milk content parameters assessed milk quality, including hygiene of the milking procedure such as urea; the shelf life could modify the pH of the milk (6.63 ± 0.06); The storage and transfer condition could keep stable milk temperature (Temp) (39.11 ± 0.84^{o}C) (Table 2).

Milk quality during months of the year in all highland and southern provinces of Vietnam is shown in Table 3. The results indicated that the average milk SCC was not different between months of the year (P > 0.05). At the same time, all other parameters differed for 12 months (P < 0.01). Larsen *et al.* (2010) found less fat in summer milk compared than in winter milk and demonstrated that climatic conditions affected the milk quality. Additionally, seasonal variations have also influenced milk content in dairy cow farms (Bernabucci *et al.*, 2015; Larsen *et al.*, 2010; Nguyen *et al.*, 2020).

Subclinical mastitis affected milk yield and quality among dairy cow smallholders

Mastitis has been known as one of the main factors affecting milk yield and quality in dairy cows (Ibrahim, 2017). Mastitis included 2 primary levels, including clinical mastitis and subclinical mastitis. Subclinical mastitis was determined by the California Mastitis Test (CMT) and the SCC method. In the present study, we examined SCC and classified SCC into 5 levels to evaluate the effect of SC on milk yield and quality. The results are shown in Table 4.

Almost milk quality parameters were the highest at the level of SCC < 200,000 cell/ml of milk, including key evaluation points such as TS (13.33 ± 0.68% at SCC < 100,000, 13.30 ± 0.60% at SCC 100,000 - <2 00,000 cell/ml), fat (4.54 ± 0.55% at SCC < 100,000, 4.50 ± 0.49% at SCC 100,000 - < 200,000 cell/ml, SNF (8.86 ± 0.26 at SCC < 100,000, 8.86 ± 0.24% at SCC 100,000 - < 200,000 cell/ml), crude protein (3.30 ± 0.26% at SCC < 100,000, 3.32 ± 0.24% at SCC 100,000 - < 200,000 cell/ml). However, from the level of SCC from 200,000 to < 400,000 cells/ml of milk, the quality of milk started to decrease and continued to decline at the level of SCC from 400,000 - < 1,000,000 cells/ml of milk, and the quality most low when the SCC of milk was higher than 1,000,000 cell/ml (P < 0.01). In detail, the results clearly showed that with a SCC lower than 200,000 cells/ml, the milk quality content of the milk remained stable within good standards (P > 0.05). When the SCC increased by more than 200,000 cells/ml of milk, the milk quality composition signal was visibly reduced and was different from the SCC level below 200,000 cells/ml of milk (P < 0.01). Differences in milk quality decline parameters continued for higher SCC levels, particularly greater than 1,000,000 cells/ml of milk (P < 0.01).

Milk production also conformed to the same principle of milk quality, which meant that milk production was higher at a SCC below 200,000 cell/ml of milk (11.12 ± 4.78 kg/cow/day at a SCC < 100,000 cell/ml, and

Table 3: The milk quality of dairy cows in households during the months of the year.

Parameters	January	February	March	April	May	June	July	August	September	October	November	December	P value
SCC (cell/ml)	425.39± 221.39	426.16± 236.90	414.02± 203.71	424.20± 200.81	429.54± 199.99	425.08± 204.11	424.71± 195.85	421.42± 209.32	413.78± 210.35	414.92± 227.44	414.01± 217.31	412.35± 226.49	0.336
TS (%)	13.01± 0.52	13.00± 0.54	13.05± 0.50	13.01± 0.49	13.00± 0.50	13.09± 0.54	13.15± 0.52	13.10± 0.538	13.09± 0.54	13.07± 0.54	13.06± 0.51	13.07± 0.53	0.000
Fat (%)	4.23± 0.39	4.24± 0.39	4.23± 0.38	4.21± 0.36	4.22± 0.37	4.28± 0.40	4.32± 0.39	5.20± 0.34	4.30± 0.40	4.31± 0.39	4.30± 0.37	4.30± 0.38	0.000
SNF (%)	8.78± 0.20	8.76± 0.21	8.78± 0.21	8.81± 0.19	8.79± 0.20	8.81± 0.21	8.83± 0.20	8.80± 0.21	8.79± 0.21	8.76± 0.21	8.76± 0.21	8.77± 0.21	0.000
Cru.Prot (%)	3.24± 0.20	3.29± 0.20	3.32± 0.20	3.26± 0.18	3.24± 0.19	3.31± 0.20	3.33± 0.20	3.34± 0.21	3.31± 0.22	3.28± 0.22	3.26± 0.21	3.26± 0.22	0.000
pH	6.64± 0.06	6.65± 0.06	6.65± 0.06	6.63± 0.05	6.64± 0.06	6.63± 0.06	6.62± 0.05	6.62± 0.05	6.60± 0.06	6.62± 0.06	6.62± 0.06	6.63± 0.05	0.000
FFA (%)	4.94± 0.79	5.22± 0.75	5.03± 0.79	5.05± 0.73	5.09± 0.82	5.51± 0.81	5.15± 0.78	5.17± 0.79	5.24± 0.85	5.51± 0.84	5.60± 0.80	5.91± 0.88	0.000
Lactose (%)	4.89± 0.11	4.98± 0.11	4.98± 0.11	4.89± 0.11	4.84± 0.12	4.84± 0.12	4.85± 0.11	4.86± 0.12	4.86± 0.12	4.86± 0.12	4.88± 0.12	4.91± 0.12	0.000
Temp (^{0}C)	39.04± 0.70	39.18± 0.78	39.42± 0.79	38.84± 0.73	38.99± 0.64	39.12± 0.64	39.13± 0.66	39.30± 0.66	39.61± 0.70	37.81± 0.61	39.43± 0.79	39.46± 0.80	0.000
Tru.Prot (%)	3.09± 0.20	3.15± 0.21	3.19± 0.21	3.15± 0.19	3.14± 0.20	3.15± 0.21	3.16± 0.20	3.14± 0.22	3.12± 0.22	3.08± 0.22	3.06± 0.21	3.07± 0.22	0.000

Table 4: Milk yield and quality at the classification of somatic cell levels

	Classification of somatic cell levels (unit: 1,000 cell/ml)						
Parameters	**<100**	**100-<200**	**200-<400**	**400-<1,000**	**≥1,000**	**Mean**	**P-value**
SCC (cell/ml)	73.20± 20.37^a	156.53± 27.70^b	303.01± 57.62^c	576.82± 139.11^d	1,153.20± 149.70^e	420.47± 213.17	0.000
TS (%)	13.33±0.68^a	13.30±0.60^a	13.10±0.52^b	12.95± 0.47^c	12.88±0.46^c	13.06± 0.53	0.000
Fat (%)	4.54±0.55^a	4.50±0.49^a	4.39±0.45^b	4.27±0.44^c	4.190.42^c	4.35±0.46	0.000
SNF (%)	8.86±0.26^a	8.86±0.24^a	8.79±0.21^b	8.76±0.19^c	8.74±0.19^c	8.79±0.21	0.000
Cru.Prot (%)	3.30±0.26^{ab}	3.32±0.24^a	3.29±0.21^b	3.28±0.19^b	3.29±0.21^{ab}	3.29±0.21	0.000
pH	6.64±0.06^a	6.64±0.06^a	6.63±0.06^b	6.63±0.06^c	6.63±0.06^{bc}	6.63±0.06	0.000
FFA (%)	5.30±0.94^{ab}	5.30±0.87^{ab}	5.23±0.84^b	5.31±0.85^a	5.45±0.89^a	5.29±0.85	0.000
Lactose (%)	4.99±0.13^a	4.95±0.12^b	4.91±0.12^c	4.85±0.12^d	4.82±0.12^e	4.89±0.12	0.000
Temp (^{0}C)	39.06±0.94	39.11±0.84	39.11±0.85	39.11±0.82	39.19±0.83	39.11±0.84	0.370
Tru.Prot (%)	3.12±0.27^{ab}	3.15±0.24^a	3.12±0.21^b	3.12±0.20^b	3.14±0.22^{ab}	3.12±0.21	0.000
Cows/household ($\bar{X}$±SD)	7.05±4.24^a	7.59±4.18^a	8.87±5.78^b	9.65±8.20^c	6.95±3.99^a	9.02±6.89	0.000
Milk yield/household/month (kg)	2,419.8± 1,925.4^{ab}	2,691.9± 1,937.2^a	3,191.1± 2,537.4^c	3,335.4± 3,101.9^d	2,136.0± 1,523.0^b	3,168.4± 2,751.7	0.000
Milk yield/household/day (kg)	79.76± 63.57^a	88.63± 63.71^a	104.94± 83.39^b	109.75± 102.16^c	70.73± 50.44^a	104.25± 90.55	0.000
Milk yield/cow/day (kg)	11.12±4.78^{ab}	11.62±3.96^{ac}	11.80±5.31^c	11.33±4.01^a	10.32±4.03^b	11.52±4.56	0.000

Significantly different values are denoted with subscripts a, b, and c (P<0.05).

11.62 ± 3.96 kg/cow/day at a SCC of 100,000 to < 200,000 cell/ml), and began to be affected by a SCC of more than 200,000 cell/ml of milk, and was slowed down by higher SCC levels, especially SCC of 400,000-1,000,000 cell/ml milk at 11.33± 4.01 kg/cow/day, SCC of more than 1,000,000 cell/ml of milk at 10.32 ± 4.03 kg/cow/day (P < 0.01). The results indicated a negative relationship between milk production, milk quality, and SCC levels in this study. Andrade *et al*. (2007) found that high SCC is associated with reduced milk production and changes in milk components (Barbano *et al*., 2006).

CONCLUSIONS AND RECOMMENDATIONS

Milk production is higher in the highlands (Lam Dong province) than in southern regions (Long An, Tien Giang, and Ho Chi Minh City) in Vietnam. Seasonal variations influenced milk production during the months of the year. At the same time, better milk quality was noted in southern Vietnam. The milk SCC indicator assessed the subclinical mastitis status at which level and showed a negative correlation between milk yield and quality among dairy cow smallholders in the highlands and southern Vietnam.

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NOVELTY STATEMENT

Subclinical mastitis affects milk yield and quality in small-scale dairy farms. This study is the first comprehensive research to give data on milk production, and seasonal variations that influenced milk production during the months of the year from dairy cows in smallholder farms in the highlands and southern Vietnam.

AUTHOR'S CONTRIBUTION

Conceptualization: TTN, TTKN, TKN. Methodology: TTN, TTKN, TKN. Formal analysis: TTN, TTKN. Writing original draft preparation: TTN, TTKN, TKN, MCH. Writing review and editing: TTN, TKN, MCH.

Conflict of interest

The authors have declared no conflict of interest.

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