The effect of different brands of automatic milking systems on bulk tank milk bacterial and somatic cell counts in dairy farms in Taiwan

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Abstract

The automatic milking system (AMS) is a new type of equipment for the domestic dairy industry in Taiwan. We introduced our first AMS in 2019, and so far a total of 25 AMS are in use. 9 farms used Lely Astronaut (Lely, Rotterdam, Netherlands) and 7 farms used DeLaval VMS (DeLaval, Tumba, Sweden). The milking equipment design and routine procedure may differ depending on the brand of AMS. Among them, the most well-known part is that the robot arms are used in industries with hydraulic drive (DeLaval VMS) or designed for animal milking with pneumatic drive (Lely Astronaut). On the other hand, the teats were individually cleaned, stimulated, and dried by cleaning teat cups with warm air (DeLaval VMS) or cleaned and stimulated by rotating brushes (Lely Astronaut). In this study, the bulk tank milk total bacterial counts (BMTBC) and somatic cell counts (BMSCC) records were collected from 3 dairy farms that have used AMS for over 3 years and have become stable in system operation and feeding management for each brand in 2023. The two brands were anonymously represented by brand A and brand B. Differences regarding these milk quality parameters were contrasted using a *t*-test. The results showed that BMTBC in brand B was higher than in brand A, with a highly significant difference ($13.47 \pm 1.39 \times 10^3$ cfu mL^{-1} v.s. $27.06 \pm 3.06 \times 10^3$ cfu mL^{-1}, $P < 0.001$). The difference in BMSCC was also significant between brand A and brand B ($171.40 \pm 7.14 \times 10^3$ cells ml^{-1} v.s. $202.90 \pm 9.65 \times 10^3$ cells ml^{-1}, $P < 0.05$). Significant differences exist among the domestic dairy industry using different brands of AMS in BMTBC and BMSCC. However, the quality of raw milk still complies with the Class A regulations on the standards of purchasing, acceptance, and pricing of raw milk. Preliminary speculation indicates that BMTBC and BMSCC are affected not only by different brands of AMS but also by different feeding management models of dairy farms. The records were collected only from 6 dairy farms. Therefore, it is expected that more dairy farms will be able to use AMS in the future and use them smoothly to provide more information for reference and stabilize the development of the domestic dairy industry in Taiwan.

Keywords: automatic milking system, bacterial counts, somatic cell counts, milk quality, dairy farm.
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Introduction

Automatic milking systems (AMS) are one of the most important technological changes in the domestic dairy industry in Taiwan. AMS can be considered not only as a substitute for milking parlors but also as a new approach to managing dairy farms (Pezzuolo *et al*., 2017). Today, AMS represents a growing reality due to lobbying for labor issues, rising costs, difficulty finding well-trained workers, and difficulty keeping people on farms (Simões Filho *et al*., 2020).

AMS manufacturers estimated that by 2020, approximately 50,000 units had been adopted worldwide (Simões Filho *et al*., 2020), with the initial introduction of commercial AMS in dairy farms occurring in the Netherlands in the early 1990s (Jacobs *et al*., 2012). The majority of these units (90%) were concentrated in Europe, with smaller percentages in Canada (9%) and other countries (1%) (de Koning, 2010). We introduced our first AMS in 2019, and so far a total of 25 AMS are in use, divided into 2 brands. 9 farms used Lely Astronaut (Lely, Rotterdam, Netherlands) and 7 farms used DeLaval VMS (DeLaval, Tumba, Sweden).

The milking equipment design, routine procedure and animal-flow models may differ depending on the brand of AMS. Among them, the most well-known part is that the robot arms are used in industries with hydraulic drive (DeLaval VMS) or designed for animal milking with pneumatic drive (Lely Astronaut). On the other hand, the teats were individually cleaned, stimulated, and dried by cleaning teat cups with warm air (DeLaval VMS) or cleaned and stimulated by rotating brushes (Lely Astronaut) (Castro *et al*., 2018). The flow systems were classified into two categories: guided flow, where dairy cows must pass through the permission gate. If cows have milking permission, they are directed to the milking waiting room; if not, they go to the resting area (DeLaval VMS). Alternatively, there is free flow, where dairy cows have unrestricted access to the milking station, resting area, and feeding area (Lely Astronaut).

This study aimed to investigate the impact of various brands of automatic milking systems on bulk tank milk bacterial and somatic cell counts in dairy farms in Taiwan.

Material and methods

Experimental design and sample collection

This study collected the bulk tank milk total bacterial counts (BMTBC) and somatic cell counts (BMSCC) records from the commercial dairy factory for dairy farmer pricing payments. Data were obtained from 6 dairy farms (3 Lely Astronaut and 3 DeLaval VMS) in Taiwan once a month from January to December 2023. These dairy farms have used AMS for over three years and have become stable in system operation and feeding management. The two brands were anonymously represented by brand A and brand B. These farms' primary breed was Holstein, and they used the free-stall barn systems. Each farm fed a different partial mixed ration twice a day, mainly composed of corn silage, alfalfa hay, and concentrate. AMS dispensers provided different amounts of commercial concentrates or feedstuffs during milking time depending on milk production, dry matter intake and days in milk.

Statistical analyses

All data were processed using GraphPad Prism version 6.0. Values of milk quality parameters were used without any transformation: BMTBC in cfu mL-1; BMSCC in cells ml-1. The difference regarding quality parameters between the two brands (Lely Astronaut and DeLaval VMS) was analyzed for statistical significance using an unpaired Student's t-test (two-tailed). *P* values of less than 0.05 (* $P < 0.05$) were used as the level of statistical significance, and *P* values of less than 0.01 (** $P < 0.01$) were indicated highly of statistical significance.

Results and discussion

Table 1 showed that throughout the whole period studied, the mean values of brand B were greater for BMTBC (27.06± 3.06×10^3 cfu mL^{-1}) and BMSCC (202.90 ± 9.65×10^3 cells ml^{-1}) than brand A (13.47 ± 1.39 × 10^3 cfu mL^{-1} and 171.40±7.14 × 10^3 cells ml^{-1}), moreover, it could be observed from figure 1 that brand A had a highly significant difference in the comparison of BMTBC. From another perspective, Table 2 showed the monthly average of BMTBC and BMSCC from different brands, also represented by a bar chart (Figure 2), it could be found that compared to brand A, the BMTBC of brand B had more significant fluctuations in different months, but in BMSCC, it is relatively stable like brand A. Therefore, it is estimated that there may be other factors affecting the quality of raw milk besides brand differences.

We investigated the application of AMS in six dairy farms and identified several factors influencing the experiment's results. These factors include the number of milking cows, the capacity of each AMS, milk yield, and milking frequency (Table 3). The number of milking cows and the capacity of each AMS directly impact the need for comprehensive care strategies and monitoring. As the number of milking cows or the capacity of each AMS increases, so does the demand for attentive management. Additionally, higher milk production requires more energy input. Increasing milking frequency helps alleviate pressure on cows' udders and decreases somatic cell and bacteria counts in raw milk.

Significant differences exist among domestic dairy farmers who use different brands of AMS in BMTBC and BMSCC. However, the quality of raw milk still complies with the Class A regulations on the standards of purchasing, acceptance, and pricing of raw milk. Preliminary speculation indicates that BMTBC and BMSCC are affected not only by different brands of AMS but also by different feeding management models of dairy farms.

Our research has uncovered a crucial issue: the number of milking cows, milk yield, milking frequency, and milk discard strategy were different between farms. However, the information provided by different AMS brands varies, leading to diverse decisions by dairy farmers regarding the milking process and discarding. This discrepancy can affect the BMTBC and BMSCC values of bulk tank milk. We understand how the technology works, and its operational procedures can assist farmers and technicians in making decisions about adopting new technology. In the future, we will continue to collect data on AMS and integrate the differences in strategies among different brands to find strategies suitable for Taiwan to maintain the high quality of AMS milk.

Table 1. The average of bulk milk total bacterial counts (BMTBC) and somatic cell counts (BMSCC) from brand A (n=3) and brand B (n=3) in 2023.

Milk quality parameters	Brand[1]		P-value
	A (n=36)	B (n=36)	
BMTBC (10^3 cfu mL^{-1})	13.47 ± 1.39[b]	27.06 ± 3.06[a]	<0.01
BMSCC (10^3 cells ml^{-1})	171.40 ± 7.14[b]	202.90 ± 9.65[a]	<0.05

[1]The data were shown as mean ± SE.
[a,b] Within the same row, values with different superscripts are significantly different (P < 0.05).

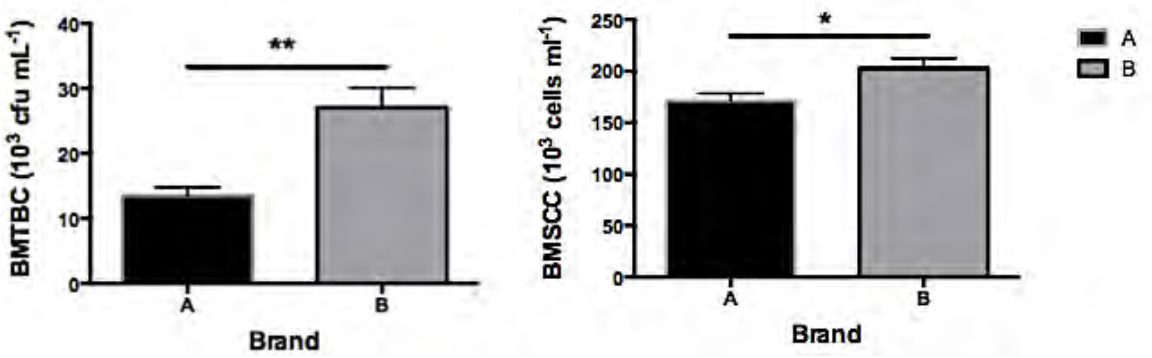

Figure 1. The average of bulk milk total bacterial counts (BMTBC) and somatic cell counts (BMSCC) from brand A (n=3) and brand B (n=3) in 2023.

Table 2. The monthly average of bulk milk total bacterial counts (BMTBC) and somatic cell counts (BMSCC) from brand A (n=3) and brand B (n=3) in 2023.

Bulk milk total bacterial counts (BMTBC)				
Brand	A (n=3)		B (n=3)	
month	Mean	SE	Mean	SE
1	9.54	1.30	44.74	27.34
2	15.62	5.87	33.04	17.31
3	11.37	2.36	20.37	4.09
4	12.26	2.94	25.20	5.22
5	11.25	5.12	49.00	20.64
6	14.25	7.58	29.32	12.57
7	13.07	5.72	21.54	3.13
8	20.23	10.79	18.36	2.50
9	15.09	3.27	25.14	4.51
10	14.10	4.68	23.36	3.01
11	7.92	2.06	17.81	3.45
12	16.90	4.62	22.79	10.85
Bulk milk somatic cell counts (BMSCC)				
Brand	A (n=3)		B (n=3)	
month	Mean	SE	Mean	SE
1	170.83	7.51	158.18	34.58
2	152.47	24.72	182.22	46.44
3	145.42	27.06	184.99	38.95
4	138.99	13.43	189.55	39.46
5	158.02	24.57	202.25	53.40
6	194.73	37.92	247.74	71.74
7	227.33	25.90	215.74	20.32
8	221.91	11.70	214.18	31.30
9	200.34	13.07	225.71	16.39
10	166.03	3.02	210.28	7.10
11	143.79	1.95	202.65	9.19
12	136.53	20.85	186.54	18.38

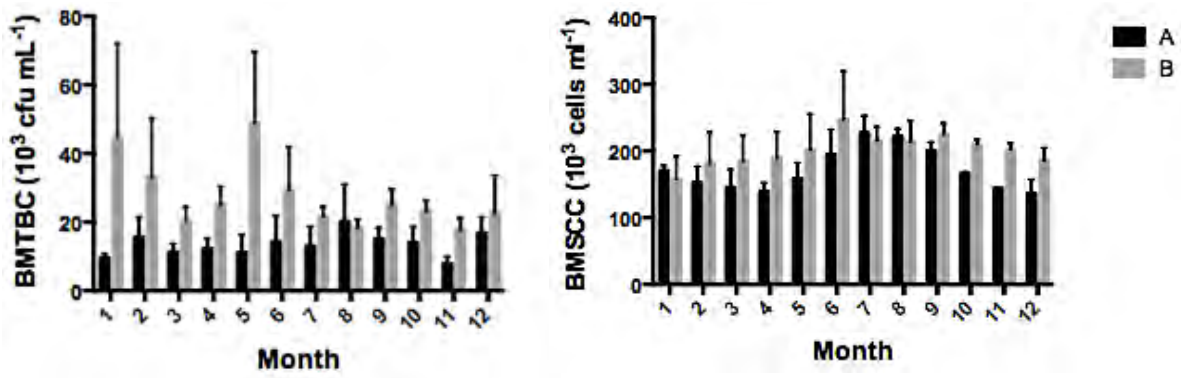

Figure 2. The monthly average of bulk milk total bacterial counts (BMTBC) and somatic cell counts (BMSCC) from brand A (n=3) and brand B (n=3) in 2023

Table 3. The average number of milking cows, number of AMS, cows per AMS, milk yield per cow per day, and milkings per cow per day in six dairy farms in 2023.

Experiment farm	Number of milking cows (no.)	Number of AMS (no.)	Cows per AMS (no.)	Milk yield per cow per day (kg)	Milkings per cow per day (no.)
A1	96	2	48	37.2	3.10
A2	76	2	38	34.3	2.90
A3	120	2	60	33.4	2.70
B1	220	4	55	31.0	2.74
B2	120	2	60	33.5	2.49
B3	48	1	48	37.3	2.25

Conclusions

The information provided by different AMS brands varies, leading to diverse decisions by dairy farmers regarding the milking process and discarding. This discrepancy can affect the BMTBC and BMSCC values of bulk tank milk. Although there is limited data collection from only 6 dairy farms, an increasing number of dairy farms is anticipated to embrace AMS in recent years. This preliminary result allows us to identify the reasons for the unstable quality of AMS milk and provides a direction for improvement in the future.

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