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A study on dairy cow management and the related bulk tank milk bacteria in Kerman County during cold and hot seasons

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Abstract

Several factors affect the quality of raw milk including the health of livestock, the milking style, and the hygiene and status of milking equipment. This study aimed to evaluate the indicator-bacteria related to the bulk tank milk management of dairy farms in Kerman County. The results will help in planning and performing good farm management practices. The bulk tank milk samples of 15 dairy farms were collected aseptically on the ice during cold and hot seasons. Total bacterial count (TBC), coliform count (CC), laboratory pasteurized count (LPC), *Staphylococcus aureus* count (SC), and somatic cell count (SCC) of the samples were assessed on every day of sampling. The questionnaires were also completed by the researchers at the farms. A mixed-design ANOVA with a significant level of 0.05 was performed to assess the interactions between different levels of management factors, laboratory results, and the seasons. During the cold season, LPCs, CCs, and SCCs were lower than in the hot season. The TBC of bulk tank milk in farms with a dirt floor was lower than other farms using concrete or roughcast ($P<0.05$). Employing milking unit workers from the farmer's family significantly reduced the CCs of the bulk tank milk. The TBC of bulk tank milk in farms that performed the teat dipping procedure before or after milking tended to reduction (despite non-statistical significance). Application of management factors such as teat drying by disposable paper towel, teat post-dipping, and dry cow therapy by long-act intramammary antibiotic ointment is considered seriously in more than 50% of the farms. Scientific education of management tips to stockmen and employment of committed workers will be very effective in the simultaneous implementation of all basic hygienic actions and therefore increasing the quality of the produced milk.

Key words: Bulk tank analysis, coliform, *S. aureus*, SCC, management

Introduction

The production of high-quality raw milk, as a major compartment of the dairy industry, is indispensable. Even by the most modern-day technologies, no one can compensate for the loss of product quality resulting from the high levels of raw milk contamination. Low quality of raw milk and a high number of bacteria in milk has an undeniable adverse effect on the quality and hygiene of dairy products, especially the fermented ones (Bonfoh et al., 2006; Dayyani et al., 2000; Szteyn et al., 2005). Mastitis, udder contamination on either internal or external surfaces, improper washing of milking equipment, and raw milk holding at high-temperature are among the most critical factors affecting the microbial load of milk (Owusu-Kwarteng et

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al., 2020). The possibility of increasing bovine mastitis, imposing financial penalties on raw milk quality, and lowing the shelf-life and marketability of milk are the results of high milk microbial load which finally affect the stockmen economy (Blowey & Edmondson, 2010).

Contaminated milking unit and farm bed along with implementing improper teat preparations protocols during washing, drying, and pre-milking, and not identifying mastitic cows can increase the total bacterial count (TBC) of milk. The coliform count (CC) is an indicator of fecal contamination. Improper teat preparation and unhygienic measures implicate a high CC. Incorrect milking machine wash process results in the growth of laboratory pasteurized bacteria in a milking system and high LPC (Blowey et al., 1997). *Staphylococcus aureus* is one of the most important microbial causes of mastitis. Milk contamination to *S. aureus* happens either by milking workers or due to the dairy cow infection. High *S. aureus* count (SC) and somatic cell count (SCC) prove herd program failure in controlling contagious mastitis. The mastitis prevention programs include teat disinfection after teat washing, applying a disposable towel in udder drying, and wearing gloves during udder preparation. The milk TBC can be reduced practically by good hygiene and management practices and implanting sanitary measures (Blowey & Edmondson, 2010).

Bulk tank milk analysis is the best way to evaluate milk quality. This analysis helps in discovering herd problems and evaluating management factors related to the microbial load of the herd milk (Blowey & Edmondson, 2010). Bulk tank milk analysis is a useful tool for herd milk quality assessment and mastitic cow trouble-shooting (Jayarao et al., 2004).

Milk quality assurance programs start by eliminating antibiotic residues and reducing bacterial and somatic cell counts in bulk tank milk. Furthermore, bulk tank milk analysis assists the manager in identifying the source of milk contaminants and rectifying the causative agents. Implementing milk quality assurance programs finally results in products with higher quality and shelf life. Accomplishing these programs in each area is a cumbersome and challenging procedure considering the geo-cultural feature of each region. The purpose of this study was to evaluate the bacterial and somatic cell properties of bulk tank milk and the effective herd management factors in Kerman County which has a desert climate with hot summers and cool to cold winters. The results will help immensely in planning and performing good farm management practice.

Materials and Methods

Herds

The bulk tank milk samples were collected from 15 dairy cow farms of Kerman County, in Kerman province, Iran. Herds had 30 to 150 milking cows. The cows were housed in open yards with shelter (14 herds) and free stalls (1 herd) and fed by alfalfa hay, corn silage, wheat straw, and concentrates. All the farms milked their cows three times daily.

Bulk tank milk samples and questionnaires

Bulk tank sampling was done twice, in the cold and hot seasons. Bulk tank Samples obtained from fresh and one-time milked batches. After agitation of milk for five minutes, a stainless-steel ladle previously sterilized by flame was used to collect milk from 10 cm of the milk subsurface. The samples were transferred to the laboratory in sterile 50 ml pots, on ice. All bacterial tests were done in less than 4 hours from sampling. A questionnaire was filled in every field to assess herdsmen, herds' management and equipment, milking routines, and milk selling style.

Bacterial tests

The TBC, CC, LPC, and SC of samples were determined. Milk samples were

diluted 10-fold serially by sterilized normal saline. Every test was performed on three different occasions in a triplicate manner.

Skim milk plate count agar (Quelab, UK) was used to determine the TBC of bulk tank milk. For TBC, one milliliter of the diluted samples was cultured by pour plate double-layer technique at 32 ± 1 °C for 72 h (Blowey et al., 1997; Jayarao et al., 2004). To estimate CC, the milk sample was cultured in violet red bile agar (Quelab, UK) by pour plate double-layer agar method, then incubated at 32 ± 1 °C for 24 h. Red colonies with a 0.5 mm diameter surrounded by a bile precipitated zone were counted as coliform (Wehr & Frank, 2004).

It is necessary to pasteurize milk before the assessment of LPC. A sterile tube was filled with 5 ml of the milk sample and placed in a 64 °C water bath for 35 min. The tube was chilled to 10 °C by cold water. The LPC of cooled milk was evaluated by the same technique as TBC (Blowey et al., 1997; Jayarao et al., 2004).

Bulk tank milk was screened for SC via a spread plate technique on Baird-Parker agar (Quelab, UK) and incubated at 37 ± 1 °C for 48 h. The black colonies surrounded by an opaque and a clear zone were considered as *S. aureus* (Blowey et al., 1997).

Direct microscopic somatic cell count (DMSCC)

The milk sample tube was heated to 40 °C and then inverted slowly 25 times. 10 µl of the milk was transferred to a predetermined 1×2 cm space of a clean microscope slide and spread carefully by a needle. Then the microscope slide was placed into a 40 °C oven for 5 min. The smear was fixed by methanol and stained by Giemsa. The mean of somatic cell counts was estimated by counting a total of 30 microscopic fields as recommended by the reference (Wehr & Frank, 2004). The microscopic factor (MF) was 380,000.

Data analysis

Data were analyzed by SPSS software (version 19). After performing the descriptive statistics, the paired t-test was used to compare parametric results between the hot and cold seasons. To evaluate the interactions between different levels of management factors and laboratory results during the hot and cold season, mixed-design ANOVA and Scheffe post hoc tests were performed. The significant level of all tests was $P < 0.05$.

Results

In the present study, the season did not affect TBCs. Coliform counts in the hot season were significantly higher than in the cold season (Table 1). Coliform count of 5 herds in the cold season were lower than 50 CFU/mL (Table 2). Cow teats were not dried after washing in two herds; common towels were used in four herds for teat cleaning, while one farm applied wet napkins without any teat washing. Pre-milking teat disinfection was performed just in one herd (Table 3).

Table 1: Bacterial and somatic cell count (log) of 15 Holstein herd bulk tank milk around Kerman County during cold and hot seasons (mean ± standard error)

	TBC	CC	LPC	SC	SCC
Standard level	4.00	1.69	2.30	1.69	5.39
Cold season	5.45 ± 0.22	2.01 ± 0.27[a]	2.87 ± 0.22	2.60 ± 0.17	5.06 ± 0.03[a]
Hot season	5.25 ± 0.13	2.73 ± 0.13[b]	2.83 ± 0.14	2.02 ± 0.26	5.99 ± 0.03[b]

[a, b] different superscripts in each column indicate significant differences ($P < 0.05$).

Table 2: Categorization of 15 dairy farms around Kerman County based on their milk quality in cold and hot seasons according to the predefined bacterial and SCC target indices

	Target indices	Cold season	Hot season
TBC (CFU/mL)	≤10000	0	0
	>10000	15	15
CC (CFU/mL)	≤50	5	0
	>50	10	15
LPC (CFU/mL)	≤200	6	2
	>200	9	13
SC (CFU/mL)	≤50	1	4
	>50	14	11
SCC (cells/mL)	≤250,000	15	0
	>250,000	0	15

In nine farms, the dirt floor was used (Table 3). This type of floor has had better drainage. The slope of the floor in seven herds was designed properly while for the rest it was not arranged decently (Table 3).

Here, the LPCs of the bulk tank milk were not significantly different between the hot and cold seasons (Table 1). Notably, the LPC of two herds in the hot season and six herds in the cold season was lower than the acceptable bulk tank standard (Table 2).

In 46.6% of herds, the routine milking system wash-up did not perform correctly (Table 3). Using hot water for rinsing was the most erroneous action in the wash-up routines.

The mean of SCs in 15 herds did not show any significant difference during the hot and cold seasons (Table 1 & 2). Respectively, during the hot and cold seasons, the SCs of four and one herd(s) were lower than the target index (Table 2).

The SCC of bulk tank milk in herds during the cold season was significantly lower than the hot season (Table 1). The SCC of all the 15 herds in the cold season was lower than the acceptable standard (Table 2). Regrettably, the managers of two herds did not perform the teat dipping procedure after milking (Table 3). In this study, the milkers of four farms used non-disposable towels for teat drying while in eight farms a disposable towel for every cow and in one farm a disposable towel for every teat drying was being applied.

The milkers of three herds used latex or rubber gloves but their coliforms and SCCs were higher than the other farms. Coliform count, TBC, and SCC of the farms which recruit their family members were lower than others. Unfortunately, the manager of eight herds did not pay any attention to the milking order of the mastitic-cows (Table 3).

Only two herds have injected with vitamin E and selenium at the beginning of the dry period within three weeks before parturition but dry cow therapy by long-act intramammary antibiotic ointment was done in 12 herds (Table 3).

Sperm selection in two herds had been performed considering the mother's udder traits. More than half of the farmers (8 of 15) had other job(s) besides the herd managing. The milk of two herds was sent just to the retail shops instead of the dairy factory (Table 3).

Table 3: Farm management-related risk factors of 15 dairy farms around Kerman County were asked on questionnaire

		No. of herd	TBC	Coliform	LPC	*S. aureus*	SCC
No. of milking cow per herd	<50	7	5.40	2.74	2.95	2.24	6.02
	50-100	3	4.86	2.26	2.67	0.89	5.86
	>100	5	5.25	2.98	2.75	2.36	6.01
duration of herding experience	<4 years	0	-	-	-	-	-
	4-8 years	5	5.59	2.33	3.25	2.36	5.02
	>4 years	10	5.37	1.86	2.68	2.64	5.07
Herd owner occupation	Only farmer	7	5.77	2.21	3.08	2.63	4.99
	As a second job	8	5.17	1.84	2.69	2.48	5.11
Milk selling place	Milk factory	11	5.19	1.91	2.85	2.59	5.09
	Retail shops	2	5.87	1.15	3.10	1.76	4.96
	Both	2	6.44	3.44	2.79	3.12	4.96
Herds workers	Recruitment workers	6	5.48	2.00	3.14^{a}	2.54	5.11
	Stochman family	1	5.77	0.85	4.57^{b}	2.48	4.89
	Both	8	5.38	2.17	2.46^{a}	2.57	5.03
Milking unit workers	Recruitment workers	13	5.49	2.30^{b}	2.82^{a}	2.55	5.07
	Family	2	5.16	0.82^{a}	3.23^{b}	2.51	4.93
Feeding time order	Before milking	1	6.63	3.04^{b}	2.80	3.57	5.00
	After milking	11	5.38	2.20^{a}	2.95	2.59	5.04
	No relation	3	5.30	1.01^{a}	2.60	2.04	5.10
Floor materials	Concrete	3	5.91^{b}	2.40	2.57	2.33	5.03
	Roughcast	3	6.05^{b}	1.29	3.66	2.54	4.96
	Dirt	9	5.09^{a}	2.13	2.71	2.62	5.09
Slope of the floor	Good	7	5.31	1.68	2.87	2.65	4.97^{b}
	Moderate	6	5.22	2.01	2.91	2.42	5.19^{b}
	Bad	2	6.61	3.20	2.78	2.56	4.95^{a}
Teat pre-dipping	Yes	1	5.41	1.98	3.54	2.13	5.25
	No	14	5.45	2.02	2.83	2.58	5.04
Order of mastitic miking	End of milking	7	5.47	1.97^{a}	3.28^{b}	2.45	5.06
	No relation	8	5.42	2.06^{b}	2.51^{a}	2.64	5.04
Teat drying	Disposable paper towel for each teat	1	5.77	2.69	3.44	3.10	4.99
	Disposable paper towel for each cow	8	5.77	2.63	2.59	2.71	5.05
	Non-disposable Paper towel for each cow	4	4.86	1.42	3.35	2.33	5.11
	No drying	2	5.15	0.40	2.76	2.06	4.98
Latex gloves application by milkers	Yes	3	5.42	2.41	3.80	2.35	5.14
	No	12	5.45	1.91	2.64	2.60	2.03
Teat post-dipping	Yes	13	5.33	2.09	2.82	2.54	5.06
	No	2	6.19	1.52	3.21	2.58	5.00
Vit E+Selenium at drying off	Yes	2	5.67	1.11	2.95	1.79	5.17
	No	13	5.41	2.15	2.86	2.66	5.03
DC ointment at drying off	Yes	12	5.60	2.19	2.90	2.59	5.08
	No	3	4.82	1.31	2.75	2.37	4.93
Cow genetic selection	Yes	2	5.62	2.50	2.44	2.53	5.14
	No	13	5.42	1.94	2.94	2.55	5.04

[a, b] different superscripts in each column indicate significant differences ($P < 0.05$) between the factors

Discussion

Milk and dairy products are nurturing environments for bacterial growth. Thus, control and supervision on sanitary milk production are vital in producing high-quality products. Different factors affect milk quality, such as herd management, milking hygiene, good bulking, and transferring to the dairy company (Blowey & Edmondson, 2010). The bacterial and somatic cell analysis of bulk tank milk is a helpful method to study the quality of produced milk and dairy herds' management.

In this study, the TBC of samples was not different between the hot and cold seasons while the CCs in the hot season was significantly higher than in the cold season (Table 1). The coliform count of 5 herds in the cold season was lower than the target level (Table 2). There are contradictory findings of the effects of season on TBC and CC. In the study of Perkins et al., TBCs were higher in the cold season (Perkins et al., 2009), but some studies have shown elevated TBC, and CC in the hot season (Elmoslemany et al., 2010; Pantoja et al., 2009; Zucali et al., 2011). It seems that the effect of season on TBC and CC depends on the region's climate and the herds' management factors. The total bacterial count would increase if there were contaminated milking machine and dirty floor, failure in mastitic cow detection, and finally applying inappropriate teat preparation protocols including washing, drying, and foremilking (Blowey & Edmondson, 2010). Fecal contamination which rises the CC happens due to weak teat preparation or unhygienic milking (Blowey & Edmondson, 2010; Jayarao et al., 2004) and also through contaminated water applies for the washing of milking machine (Jayarao et al., 2004).

For sanitary milking, teats should be washed carefully and dried by disposable towel because the remaining water on teats –so-called 'magic water' for its high bacterial contamination– could increase TBC, CC, and the risk of environmental mastitis (Blowey & Edmondson, 2010; Murphy & Boor, 2000). In this study, the workers of two herds did not dry the teats after washing while 60% of the farms were applying disposable paper towels for teat drying (Table 3). It has been shown that milking cows with dirty teats increases TBC and CC in the bulk tank milk (Elmoslemany et al., 2009b; Pantoja et al., 2009). Pre-milking teat disinfection was performed in around 6.6% of the herds (Table 3). Pre-milking teat disinfection reduces the number of milk bacteria and clinical mastitis prevalence (Blowey & Edmondson, 2010). This procedure also induces around a 50% decline in new coliform infections (Philpot & Nickerson, 2000).

Floor material and its slope affect water drainage of bedding and teat contaminations. Hence, cows housing in a clean and dry place reduces the prevalence of environmental infections (Bartlett et al., 1992) and dirty housing increases the risk of mastitis (Schukken et al., 1990). The dirt floor which has better drainage was used in nine herds while 86% of the farms' floor had a moderate to a good slope (Table 3). Poor floor slope designing produces troubles in the rainy season. In 53.3% of the assessed herds, there was no attention to the order of the mastitic cows milking (Table 3). This mismanagement increases the spread of contagious infections and the risk of subclinical mastitis and finally results in high SC, SCC, and even TBC of the bulk tank milk.

In the present study, the LPC of 40% and 13.3% of the herds was lower than the standard level during the cold and hot seasons, respectively (Table 2). Hygiene of the milking system is one of the most important factors in producing high-quality bulk milk (Elmoslemany et al., 2009a). High LPC of the bulk tank milk is an indicator of problematic procedure in milking machine and bulk tank washing (Blowey & Edmondson, 2010). 53.3% of

the herds performed the routine milking system washup correctly (Table 3). A correct routine milking system washup involves rinsing by warm water (38-43 °C), washing by 60-70 °C detergent solution, and at last disinfection (Blowey & Edmondson, 2010). Acid washing should be done about every week–depends on the water hardness– to clean sediments of milk in the milking system because milk stones could increase TBC (Elmoslemany et al., 2009b). In this study, the application of hot water in the rinsing stage was the most erroneous action. Hot water denatures proteins and causes more problems in equipment washing.

The mean of SCs in 15 herds did not show any significant difference in the hot and cold seasons (Table 1). Notably, the SCC of the bulk tank milk in the hot season was significantly higher than the cold season and the SCC of all 15 herds in the cold season was lower than the acceptable standard (Table 1 & 2). Somatic cell counts could be increased during summer because of the prevalence of intramammary infections and stresses such as heat stress and changes in feeding ingredients (Suzuki et al., 2020; Riekerink et al., 2007; Green et al., 2006; Harmon, 1994). Also, flies are more abundant during summer and act as a vector for contagious organisms of subclinical mastitis (Blowey & Edmondson, 2010). Similarly, it has been shown that SCCs arise during summer in Iran (Najaf Najafi & Mortazavi, 2009). High SCC and SC of bulk tank milk are indicators of subclinical mastitis in herds and show the failure of preventive programs in control of the contagious organisms (Blowey & Edmondson, 2010; Murphy & Boor, 2000).

Post-milking teat disinfection, teat-drying by disposable towels, and using latex gloves by milkers during teat preparation are some of the most important acts in preventing contagious infections (Blowey & Edmondson, 2010). Here, post-milking teat dip did not perform in two herds (Table 3). The thin milk layer on teats provides a good environment for bacterial growth. Post-milking teat disinfection inhibits the growth and colonization of contagious bacteria on the teat and has decreased SCC in herds (Barkema et al., 1998). In the present study, teats were dried with non-disposable towels in four herds, whereas nine other herds were using disposable paper towels (Table 3). Teat drying by disposable towels decreases TBC and CC, limits the spread of the contagious organisms, and improves the final quality of milk. Latex or rubber gloves were used by milkers in 20% of the evaluated herds (Table 3). Rough surfaces of hands hardly disinfect and using rubber gloves is important to prevent teat infections with contagious bacteria of mastitis especially *S. aureus* and *Streptococcus agalactiae*. These bacteria are present on the hands of half of the milkers even before milking. Notably, *S. agalactiae* has been detected on the milkers' hands up to 10 days after contacting an infected cow (Blowey & Edmondson, 2010).

80% of the assessed herds performed dry cow therapy by long-act intramammary antibiotic ointment (Table 3). Such protocols at the end of lactation treat subclinical and hidden mastitis that remained from the previous lactation period and decreases the risk of environmental mastitis during the dry period (Blowey & Edmondson, 2010). Lower SCC has been reported from bulk tank milk of herds using dry cow treatment (Barkema et al., 1998). Furthermore, the application of vitamin E and selenium during the dry period of dairy cows is being advised to support the cellular immune system against bacterial invasion by protecting them from free radicals. Only two herds had injected this preparation at the beginning of the dry period within three weeks before parturition (Table 3).

Genetic selection for correcting udder structure and enhancing the resistance of cows to mastitis is one of the best and fundamental methods to improve the

quality indices of milk mostly bacterial and cellular ones (Devani et al., 2019). In this study, two herds had a history of sperm selection regarding the mother udder traits.

In recent years, retail shops with traditional dairy products are propagated. The quality of the raw milk for these retail shops is hardly being controlled, hence, lots of hygienic actions might be neglected. Two farms sent their milk just to these retail shops instead of the dairy factory (Table 3). 53.3% of the farmers in this evaluation have been involved in other jobs besides herds managing (Table 3). Dairy herd management is an elaborate and toilsome job. Hence, engaging in multi-jobs besides farming could decrease the stockmen focus on the farm duties which affects milk quality.

Conclusion

Indices of good milk quality and the subsequent protocols for farmworkers are introduced for more than five decades. To achieve high-quality standards in milk production, the farm should consider all of the protocols, concurrently. In our study, there were no herds considering all of the basic hygienic actions for producing milk with acceptable quality indices. Application of just DC ointment at drying off, disposable paper towel, and teat post-dipping are actions that were considered in more than half of the farms. Hence, we did not have a herd showing all the acceptable target indices at once. It seems that establishing centralized mega-farms with united managing protocols along with training committed and professional works is the key to promoting milk quality indices.

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Conflict of interest

The authors declare that they have no conflict of interest.

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ارزیابی شاخص‌های باکتریایی مرتبط با مدیریت در مخزن شیر گاوداری‌های شهرستان کرمان در دو فصل سرد و گرم

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چکیده

چندین عامل بر کیفیت شیر تولیدی در گاوداری‌ها مؤثر است که از جمله آن‌ها سلامتی دام‌ها، نحوه‌ی شیردوشی و بهداشت تجهیزات شیردوشی می‌باشند. هدف از این مطالعه ارزیابی شاخص‌های باکتریایی مرتبط با مدیریت در مخزن شیر گاوداری‌های شهرستان کرمان بود که می‌تواند در طرح‌ریزی و اجرای برنامه‌های مدیریتی کمک کننده باشد. نمونه‌های مخزن شیر از ۱۵ گاوداری در ظروف استریل در دو فصل سرد و گرم جمع‌آوری شد و جهت انجام آزمایشات باکتریایی در همان روز به آزمایشگاه منتقل شدند. شمارش کلی باکتریایی (TBC)، کلیفرم‌ها (CC)، باکتری‌های مقاوم به پاستوریزاسیون (LPC)، استافیلوکوکوس آرئوس (SC) و سلول‌های پیکری (SCC) در همان روز نمونه‌گیری انجام شد. تکمیل پرسشنامه‌ها نیز در گاوداری صورت پذیرفت. طرح آمیخته ANOVA با سطح معنی‌داری ۰/۰۵ برای ارزیابی اثرات متقابل بین سطوح مختلف عوامل مدیریتی، نتایج آزمایشگاهی و فصل انجام گرفت. در فصل سرد، LPC، CC و SCC کم‌تر از فصل گرم بود. TBC در گله‌هایی که جنس بستر از خاک بود کم‌تر از گله‌هایی بود که از سیمان یا شفته استفاده کرده بودند. در گله‌هایی که اعضای خانواده خود گاودار کار شیردوشی را انجام می‌دادند CC به طور معنی‌داری کم‌تر بود. ضدعفونی پیش یا پس از دوشش سبب کاهش غیرمعنی‌دار TBC در مخزن شیر شده بود. به کار گیری عوامل مدیریتی چون خشک کردن سرپستانک‌ها با حوله‌ی کاغذی یک بار مصرف، ضدعفونی پس از دوشش و درمان گاوهای خشک با پمادهای پستانی در بیش از ۵۰ درصد گله‌ها مورد توجه بود. آموزش علمی نکات مدیریتی به گله‌دار و کارکنان، در اجرای همزمان همه‌ی فعالیت‌های بهداشتی پایه بسیار مؤثر بوده و می‌تواند منجر به افزایش کیفیت شیر تولیدی شود.

کلمات کلیدی: آنالیز مخزن شیر، کلیفرم، استافیلوکوکوس آرئوس، شمارش سلول‌های پیکری، مدیریت

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