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INFLUENCE OF MANAGEMENT PRACTICES ON SOMATIC CELL COUNT AND TOTAL BACTERIA COUNT IN COW'S BULK TANK MILK

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Abstract

Improving of the hygiene and the milk quality is a common interest of both its consumers and the farmers. The goal of this research was to determine the management practices which lead to improvement of the hygiene and the quality of the bulk tank milk in accordance with the current regulations.

The subject of the research were Holstein Friesian cows, (N = 520), kept in tied up system and milked separately. The results obtained from 730 raw milk samples which were tested for their physical and chemical parameters using an infrared analyser Milcoscan, pH meter Metller Toledo and thermometer (proteins, milk fat, dry matter, pH, temperature) and their microbiological parameters (somatic cells (SCC) (Fossomatic 5000) and total bacteria count (TBC) (BactoScan) within a period of two years. A face to face survey was conducted with the farmer at the end of the first year, in reference with the milking procedure and the manner of the building and the milking equipment cleaning. The survey results were processed and some correctional measurements were applied with the purpose of improvement of the hygiene and the milk quality.

The following results were reached during this research: the average number of SCC on the farm during the first year was 304.17 x 10^3 cells/mL, and after the application of the correctional measurements that number diminished to 129.05 x 10^3 cells/mL. Also, a decrease was recorded in the average number of microorganisms which number from 163.84 x 10^3 cells/mL in the first year dropped to 56.29 x 10^3 cells/mL in the second year. No changes in the physical and chemical properties of the milk were registered. Management practices associated with low SCC included the use of teat disinfection post-milking, correct udder preparation and milking.

At the farm level, the incorrect maintenance of the milking equipment and the insufficient level of hygiene in the building proved as a source of bacterial contamination.

***Key words**: Management practices, SCC, TBC, Cow, Bulk tank milk.*

1. Introduction

The food safety should be compulsory in every phase of the production chain, and the primary level of production is the first step which means that the dairy quality is closely connected to the activities that take part in the production process that happens on the farm itself [1]. The dairy products quality is largely dependent on the raw milk quality because bacteria can have a negative effect on dairy products, for example, *Alteromonas putrefaciens* causes a surface taint in butter, and *Escherichia coli* can spoil milk and dairy products by gas production during storage [2]. The increased number of SCC also has negative impact on the raw milk quality [3]. As a result to the somatic cells number increase, the milk has a diminished technological quality, the cheese yield and quality is as well decreased, the pasteurized milk shelf life is shortened, and unwanted odors can appear with these products [4], and [5].

In order to get hygienically sanitary milk it is necessary that the animals are healthy, and this especially applies to the mammary gland. The somatic cells (SCC) and the total number of microorganisms (Total bacterial count - TBC) are parameters to follow the milk hygienic standard. An SCC < 100,000 cells/mL is reported to be normal in a healthy mammary gland [6], whereas SCC > 200,000 cells/mL is suggestive of bacterial infection [7].

The improvement of the health and the well-being of the milking cows have lately reached a higher level in some our farms. The precautions that need to be taken in order to improve the zoological and the sanitary conditions are an important management practice which plays a crucial role in the process of getting a high quality raw material which will satisfy the demands of the producers and the consumers [8]. Therefore, it is a necessity to implement work protocols which would precisely define the manner of work on a farm, such as protocols for: milking, milk cooling, cleaning, etc. The various researches has shown that the TBC can be reduced within a certain time frame with application of good hygiene and farm management practices.

The aim of his research is to determine the influence and the connection of the management practices and work protocols that affect the total number of bacteria and somatic cells. Management practices associated with low SCC included the use of post-milking teat disinfection, correct udder preparation and milking. At the farm level, the incorrect maintenance of the milking equipment and the insufficient level of hygiene in the building proved to be a source of bacterial contamination.

2. Material and Methods

Data were collected from 520 (N=520) dairy Holstein Friesian cows which were milked in the separate milking in tied up system. The results obtained from 730 raw milk samples were tested for their physical and chemical parameters and their microbiological parameters somatic cells (SCC) and total bacteria count (TBC) within a period of two years. The average milk quantity amounted 6146 kg and 6689 kg of milk in 305 days lactation for the first year and second year, respectively.

For the research, 200 mL of milk were collected in sterile plastic cups at the end of the day (morning and afternoon milking combined). The temperature of the tank was recorded every 2 hours and the milk was kept on < 6 ^{0}C at all time. Before collection, the milk was stirred by the agitator of the tank for 5 minutes. Milk samples were taken to the laboratory immediately after collection and were kept at 4 ^{0}C until laboratory analysis. The analysis of the chemical composition of the milk means determining milk: fat content, protein, and dry matter using infrared analyzer Milkoscan in accordance with the IDF 141C:2000 standard. The pH value was measured with a pH meter Metller Toledo. The cell count was determined with Fossomatic 5000 and milk - enumeration of somatic cells was done according to ISO 13366/2:2006 standard. The working principle of Fossomatic 5000 consists of somatic cells staining and electronic counting. The hygienic quality of the milk was estimated on the basis of the total bacterial count (with the IDF 161A:1995 reference method as well as with the BactoScan FC apparatus).

The results thus reached were statistically processed in the usual variation and statistical methods in Microsoft Office Excel. The arithmetic mean value, the variation index, standard deviation and the median were calculated and with a t-test the statistical significance of the differences between the two years was determined at the level of $p < 0.01$ and the results are shown in Figures below.

The survey designed to determine the influence of the management practices on the number of the microorganisms and the somatic cells in raw milk was conducted at the end of the first year of the research. It was conducted on the farm with personal face to face interviews with the farmers and in this way information were collected in regards of: herd number, milking procedure (the manner of udder preparation, disinfection prior and post milking, milking of cows which are suffering from mastitis, vacuum and pulsation level), manners of the building (the frequency of mat application) and the milking equipment cleaning (cleaning of the milking units and the tank). The survey results were processed and some correctional measurements were applied with the purpose of improvement of the hygiene and the milk quality.

3. Results and Discussion

The target of this research were cows kept in a tied up system, which means that they are more prone to occurrence of mastitis than the cows which are kept freely in their stalls [9], and the causes of mastitis in these two keeping systems are different [10]. The features of the farm in the course of the first year of the research are shown in Table 1.

Table 1. Farm features in the first year

Farm features in 2012 year	
Farm size	520 cows
Manner of keeping the cows	Tied up
Manner of milking	Separate milking
Udder preparation	Washing with clean water and drying with towels
Pre-milking disinfection	No
Post-milking disinfection	No
Hygiene of the stalls and mat substitution	Unsatisfactory, once per day
Cleaning of tank	Daily
Milking of mastitic cows	Last

Before the milking it is crucial to check the milking equipment in detail, the proper hygiene of the person who performs the milking and wearing gloves as a part of the milking protocol, which was an exception in this case. Effective pre-milking udder hygiene is important for the production of high quality milk and the control of mastitis [11]. Unclean udder and teats are carriers of bacteria of the surroundings and because of this reason they need to be washed, dried and disinfected in order to get quality milk [12]. The cleaning of the udder before milking was done by washing with warm water, but there was not thorough drying of the teats. Manual drying of the teats is an important step for reducing bacterial burden of the teats [11]. Pre-dipping followed by drying the teats with single-use towel was associated with the lowest bacterial counts compared to other methods of teat preparation [11], which was an exception in this case, as drying was executed by towels which were consecutively used on several cows, and these were substituted with single-use towels during the second year, because sharing the same towel between cows increases the risk of transmission of mastitis pathogens among animals and reduces the efficiency of drying of the teats [11].

Prior to the milking, there was no teats disinfecting, and this is important as the number of the bacteria in the bulk milk is significantly reduced with the use of disinfection liquid before the milking procedure [13]. Teat disinfection is compulsory after milking, as the sphincters of the teat take approximately 15 minutes to close the entrance and to prohibit microorganisms from entering [12]. To disinfect the teats after the milking procedure, it is necessary to use such disinfectants that do not harm the teats' skin, that help the lesions' healing, destroy all the causes of mastitis on the teats themselves after the milking, have continued effect, prevent the contamination of the udder between two milking procedures and do not affect the health sanitation of the milk. Therefore, in the second year of the research, the use of iodoform as disinfectant in a concentration of 1% was introduced as part of the corrective measurements. The udder disinfection with iodoform prior and after milking, as well as cleaning with clean water reduces the risk of new infections and it leads to decrease of the somatic cells and microorganisms in the bulk milk ([14], [15], and [16]). The milking procedure was standardized and the milking protocols were precisely followed in the course of the second year.

Mastitis check tests were not used and the usage of California Mastitis Test (CMT) is related to a low number of somatic cells [17]. Furthermore, the milking of the first jets of milk was normally made on the floor. The vacuum used on the farm was 40 - 45 kPa, and the pulsation number was 50 - 55, and in several cases there was ineffective milking of the cows. The somatic cells number is the lowest with an average number of pulsations between 46 and 54, which matches the recommended value of 50 ± 4, and with reducing or increasing the number of pulsations, the number of somatic cells grows. The ratio can be 50 : 50, 70 : 30, and 60 : 40 in the phase of milking and resting, respectively [18]. The recommended vacuum levels are 48 - 50 κPa for high vacuum, 46 - 48 κPa for medium and 42 - 45 κPa for low vacuum [19].

The improper cleaning of the milking equipment, the mastitis and the unsatisfactory cooling of the milk affects the increase of the total number of microorganisms in the bulk milk [20]. Cleaning of the milking equipment was executed by dipping milking units in a disinfecting solution after every milking which diminishes the transfer of microorganisms on the consecutive cows. This largely lowers the number of microorganisms in the rubber of the cup, but it does not significantly reduce the new inflammatory infections [21]. If the system is contaminated, there are going to be more microorganisms that would multiply and end in the bulk milk [22]. Manual cleaning, along with lower temperatures and lower frequency of detergent and acid use was associated with increased bacterial contamination of bulk tank milk [11], and as of this reason, the tank was cleaned in several phases: right after the emptying of the milk, first with clean lukewarm water (37 ^{0}C), an alkaline solution is made in a bucket, with a concentration of 1 - 2% at the temperature of 60 - 80 ^{0}C, at the time frame of 20 - 30 minutes and it is manually cleaned with brushes. Then, it is rinsed with warm water until there are no residues of the cleaning solution. Once a week, it should be washed with acid solution, in a concentration of 1 - 2% at the temperature of 40 - 80 ^{0}C in a time frame of 20 - 40 minutes and then, it is rinsed with clean water.

Regarding the stalls hygiene maintenance, it was noticed that is necessary to change the matting more frequently, as it was only changed once a day, and there were milk residues at some stalls. Because of this reason, in the second year, the corrective measurement of changing the matting twice a day was introduced. The matting is a serious factor of milk contamination, as the straw from the matting can contain 7 - 10 million of microorganisms in one gram [23]. Cows affected by mastitis were milked last and the cups were disinfected after their milking.

The results of the average values of somatic cells and the total number of microorganisms in the bulk milk are presented in Table 2. It can be noticed that the introduction of the corrective measurements has resulted with a change of the raw milk quality, and there is a statistical significance at the level of $p < 0.01$ between the total number of bacteria in the first and in the second year of the research. The results are also represented graphically by months (Figure 1).

Table 2. Average values of the hygienic parameters in raw milk (N = 520)

Statistical measurements	CFU x 10^3/mL	SCC x 10^3/mL	CFU x 10^3/mL	SCC x 10^3/mL
	2012		2013	
$\bar{x}$	163,84[a]	304,19	56,29[b]	129,05
Max x 10^3/mL	458	426	66	213,2
Min x 10^3/mL	75,5	239,33	46	93,04
SD	117,02	65,50	6,95	33,70
CV%	71,42	21,53	12,34	26,12
Median	111,96	279,92	56,75	123,45

*The differences in the values with different superscripts are statistically significant at the level of $p < 0.01$: a:b

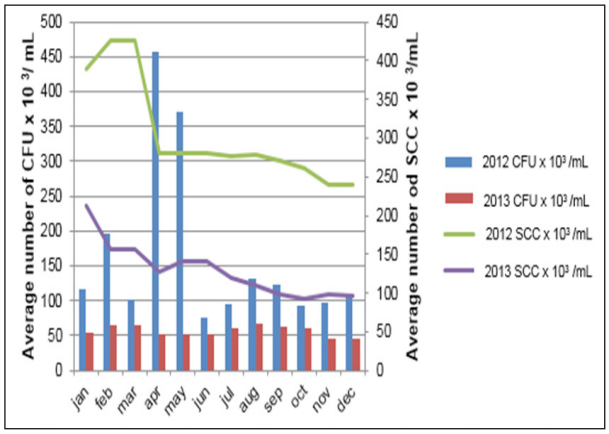

Figure 1. Average values of the hygienic parameters in raw milk (N = 520)

The bacteriological quality of the milk is a basic marker of the hygiene in the primary production. Non-standard sanitation procedures in milk production contributed to the great variability and the high variation index of 71% with CFU/mL within the first year, while as it lowered to 21.34% in the second year. Regarding the SCC/mL the variation index is 21.53%, and in the course of the second year it increased to 26.12%. The standard deviation in the first year is high for both the parameters CFU/mL and SCC/mL, 117.02 and 65.50, respectively. The average somatic cells number is in accordance with the specified minimum of 400,000/mL and the total number of microorganisms in the first year is above the allowed law restrictions for that year [24] and the milk belonged to I class [25]. In the second year, however, the number of somatic cells and microorganisms completely complies with the newly established demands [26] and there is an Extra class of milk [25].

At the farm level, microbial contamination of bulk tank milk (BTM) occurs via 3 main sources: bacterial contamination from the external surface of the udder and teats, from the surface of the milking equipment, and from mastitis organisms from within the udder [17]. Bacteria deposited in the milking and milk handling equipment will multiply and become a major source of contamination if equipment is not cleaned and sanitized properly [27]. When the bacteria enter the udder, the cow's organism responds in the way that it sends a great amount of white blood cells to the mammary gland and from there, in the milk. They surround the bacteria and destroy it. This is one of the most important defense mechanisms that the cow uses to handle the udder infection. A small number of cells (around 2%) enter the milk through the udder tissue. These cells come from the cow body. They are not bacteria cells and they are called somatic cells. The number of somatic cells does not rise after the milking, regardless of the filtration and the cooling conditions.

Bulk Tank Milk (BTM) SCC is a general indicator of the udder health in a herd and it is also regarded as an indirect measure of milk quality [28]. Among the many management practices in dairy herds, only a few are directly related to the number of somatic cells in milk [29]: use of dry cow therapy, participation in a milk recording scheme, use of teat disinfection post-milking, overall hygiene [30], milking mastitis cow's last, annual inspection of the milking system, wearing gloves during milking, using California Mastitis Test [29], high vacuum and number of pulsation of the milking machines [31], as well as problems with the milking equipment and the cooling [32]. A certain level of somatic cells is always present in milk, as a protection for the cow against mastitis infection [33]. However, it must be taken into account that many management practices in mastitis control programs are primarily introduced to prevent the clinical forms of mastitis, and not a high number of somatic cells in bulk milk. These are important management practices that are associated with udder health in cows [17]. The factors that affect the mastitis occurrence are: herd management 49%, genetics 20%, accommodation 25% and the milking apparatus 6% [34].

The results of the physical and chemical examinations are shown in Table 3, and there it can be seen that the applied corrective measurements have not directly influenced the chemical composition of the milk.

Table 3. Average values of the chemical composition of the raw milk during the years of examination (N = 520)

Statistical measurements	Milk fat %	Protein %	pH	Dry matter (solids non-fat - SNF) %	Temperature ^{0}C
2012					
$\bar{x}$	3.74	3.37	6.04	8.55	5.65
SD	0.09	0.05	0.02	0.05	0.45
CV%	2.44	1.39	0.30	0.64	8.26
median	3.68	3.35	6.02	8.52	5.52
2013					
$\bar{x}$	3.83	3.41	6.01	8.59	5.69
SD	0.07	0.06	0.01	0.07	0.66
CV%	1.76	1.81	0.25	0.86	11.57
median	3.81	3.41	6.005	8.56	6.03

Even though the milk fat is the most variable component in the milk, in our research it had an equal annual average of 3.74% in the first year and 3.83% in the second one and it has got a low variation index. The protein was at the boundary between 3.37% and 3.41% for the first and the second year, respectively. Dry matter was within the limits of the legal minimum which amounts 8.50%. The active acidity (pH) showed quite close values within these two years, 6.04 and 6.01 pH units respectively, which does not comply with the legal minimum settled at 6.5 - 6.75 pH units. The most frequent changes in the pH values of the milk happen when there is occurrence of mastitis in cows, when they drop to alkaline area (pH > 7) and development of microorganisms when the pH values diminish [31]. The milk was cooled at the temperature of < 6^0 C which is in accordance with the legal demands of milk cooling [26].

4. Conclusions

- This paper describes the general features of the farm and the work protocols used there. It also shows that the different management practices and the application of corrective measurements largely influence the total number of microorganisms and somatic cells in bulk milk and this also increases the raw milk quality.

- The average bacteria number is 163.84 x 10^3/mL in the first year and 56.29 x 10^3/mL in the second year. The total number of somatic cells amounts 304.17 x 10^3/mL and 129.05 x 10^3/mL in the courses of the first and the second year, respectively.

- The chemical composition of the milk does not show any statistically significant features.

- Management practices connected to the lowering of the number of somatic cells are use of disinfection solutions and correct udder preparation, and milking procedure. Moreover, the maintenance of the milking equipment and the general hygiene on the farm, affect the reduction of the total number of bacteria.

- The goal of each farmer should be improvement of the quality of the milk on their farm and that would lead to mastitis, as one of the most expensive conditions, to become rarer.

5. References

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