Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v45i1.58353

ANIMAL PRODUCTION

Quality of refrigerated raw milk according to the bulk transport conditions

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ABSTRACT. Technical regulations that determine milk quality standards in Brazil establish the minimum criteria that the processing industry's raw material must present. These rules can challenge the logistics sector (transport) to maintain adequate milk conservation levels. We aimed to evaluate the influence of bulk transport and storage conditions on refrigerated raw milk quality. The experiment was carried out in a dairy industry in Santa Catarina State. Information and samples of refrigerated raw milk were collected from dairy farms, from isothermal compartments of milk trucks, and from the industry's storage silo. These samples were submitted to microbiological analysis, somatic cell count (SCC), and physicochemical analysis. The results were evaluated by ANOVA and multivariate analysis (factor analysis). The transport of raw milk in bulk and the transfer of raw material to the industrial silo worsened the milk's microbiological quality ($p < 0.0001$) for standard plate count (SPC) and psychrotrophic microorganism count (PMC), without affecting, the physicochemical characteristics of the milk ($p > 0.05$). Poor hygienic conditions in milk storage rooms, in the refrigeration bulk tanks of the dairy farms, and during the transport, as well as the transport on longer routes, were related to higher SPC and psychrotrophic count while receiving milk by the dairy industry with higher temperatures was only associated with higher SPC.

Keywords: microbiological quality; psychrotrophic microorganisms; standard plate count.

Received on March 23, 2021.
Accepted on April 13 2022.

Introduction

The mandatory storage of milk under refrigeration from the dairy farm to the processing establishment was part of a series of rules established in Brazil by the National Plan for the Improvement of Milk Quality (PNMQL). This plan's guidelines culminated initially in Normative Instruction 51/2002, which was followed by several legal publications that established the minimum rules for maintaining the quality of raw milk in the different stages of the milk production chain. They were recently consolidated by Normative Instructions n. 76 and 77/2018 of the Ministério da Agricultura Pecuária e Abastecimento – MAPA (Instrução Normativa nº 51, 2002; Instrução Normativa nº 76, 2018; Instrução Normativa nº 77, 2018). These regulations innovated bulk transport, establishing some new criteria, like the maximum temperature of 7°C for receiving milk in the industry and maximum standard plate count (SPC) of 900,000 colony forming units (CFU) mL^{-1}, before milk processing (Instrução Normativa nº 76, 2018).

The hygiene conditions for obtaining and storing milk on dairy farms, and the conditions under which bulk milk transport is carried out, directly affect the quality of milk and dairy products. The transport of raw milk has several challenges to reach high microbiological quality, such as awareness of the importance of milk quality and technical knowledge of transporters, precarious roads, time and temperature of storage, and mixing of milk from different dairy farms with heterogeneous quality (Cunha, Parreira, Silva, & Cerqueira, 2013). The microbiological diversity of raw milk in truck tanks alone varies considerably according to the season and individual management conditions of each supplier. In this context, it is essential that the dairy chain, from the farm to the industry works correctly, and that bulk transport does not become an aggravating factor as a source of milk contamination (Kable et al., 2016).

The refrigeration of milk in dairy farms aims to reduce the development of harmful acidifying effects of mesophilic microorganisms. However, when hygiene conditions in obtaining and storing the milk are poor, keeping milk at low temperatures for prolonged periods decreases the proportion of mesophiles, favoring the psychrotrophic microbiota development. Psychrotrophic microorganisms are well adapted to refrigeration temperatures. They can produce lipolytic and thermostable proteolytic enzymes, which have already been associated with several technological problems and sensory changes in milk derivate (Santos, Cerqueira, Leite, & Souza, 2018; Nörnberg, Tondo, & Brandelli, 2009). UHT milk and powdered milk are susceptible to the residual activity of heat-stable peptidases that cause bitterness, the formation of suspended particles, creaming, and gelling and decreasing all casein fractions in the milk. These conditions interfere with the clotting time, rennet, and clot firmness in cheese production (Paludetti, Kelly, & Gleeso, 2020; Zhang et al., 2015). These enzymes also affect the percentage of yogurt's protein and pH, causing a decrease in shelf life and a bitter taste in the products (Fagnani, Schuck, Botaro, & Santos, 2017).

Most scientific studies on the effect of bulk milk transport on milk quality only address SPC, SCC (somatic cell count), and milk's chemical composition (Silva et al., 2009; Brasil et al., 2012). Few studies have quantified the psychrotrophic count in milk during bulk transport and the effects on its quality, or, have carried out a multifactorial assessment of the poor milk quality causes. In these studies, transportation to the processing industry assessed only a few samples of farms and truck tanks. Some of them were collected at a temperature above the current normative recommendations, with short distances traveled between the farms and the processing industry, and made use of conventional statistical techniques, limiting more comprehensive conclusions on the topic (Mörschbächer, Rempel, & Maciel, 2017; Almeida et al., 2017). Multiple factors can influence the quality of milk that arrives in the industries. In these complex situations, data evaluation using multivariate statistical techniques is the most suitable since they can demonstrate the effect of more than one factor, and the relationship between the correlated variables in the result (Alessio et al., 2016) as well. Thus, the objective of this study was to evaluate the consequences of the conditions of milk storage on the farms and bulk milk transport on the psychrotrophic count, SPC, and physicochemical characteristics of refrigerated raw milk received in the dairy industry.

Material and e methods

The study was carried out in partnership with a dairy industry from the Region of Vale do Itajaí, Santa Catarina State, Brazil, in the first semester of 2016. Six trucks were followed at random, on nine trips, on their daily milk collection lines. The carriers were outsourced, and the collection routes ranged from 134 to 486.8 km, with collection times between 3.85 to 13.55 hours.

Samples of raw milk were taken from storage tanks at 147 dairy farms (with daily milk production ranging from 16 to 975 liters) and from 17 isothermal truck compartments on the industry receiving platform. Before the collections, a checklist was filled out to obtain general information about the hygienic-sanitary conditions of the milk room, the milk storage tank, and the truck (external, compartments, connection, and hose) used for milk transportation. The evaluations were made by a visual score, classified as: terrible, bad, reasonable, good, and excellent, been the visual scale transformed into grades from 1 to 5, respectively. The milk volume collected in each dairy farm, in which the isothermal compartment of the trucks was allocated, the milk's temperature (before collection), the kilometers, and the route time (counted from the first dairy farm collected), were recorded.

The milk stored in the industry silo was also evaluated by taking milk samples every hour for five hours after unloading the raw material. These samples represented the dairy industry's daily reception of milk, which came from different milk collection routes and trucks. All samples were collected after temperature measurement, homogenization, and sterilizing of the material used for the sample collection. For microbiological analyzes (SPC and psychrotrophic count), milk samples were collected in sterile bottles containing the bacteriostatic agent Azidiol®. Hahne, Isele, Berning and Lipski (2019) showed that preservation with Azidiol® had no significant bactericidal effect on the SPC of raw milk. Furthermore, in a study on sheep milk stored in an industrial silo, Garnica, Santos, and Gonzalo (2011) the use of the preservative Azidiol® was compared. The study shows that the azidiol® preservation maintained the initial bacterial concentration, including the psychrotrophic count, in raw sheep milk under refrigeration throughout 96 h. Because we had different distances between the farm and the dairy industry and different routes distance, we collected the samples with the use of the preservative Azidiol®. This approach aimed to maintain the psychrotrophic count constant, with a level that reflect the collection moment at the farm. The samples were diluted in sterile peptone saline solution, from 10^{-1} to 10^{-4} and the psychrotrophic count was done according to American Public Health Association standard methods, described by Frank and Yousef (2004).

The samples destined for physicochemical and milk composition analyses were collected in sterile bottles without preservatives and in bottles containing Bronopol®, respectively. The physicochemical analyzes of pH and titratable acidity followed the determinations of American Public Health Association standard methods. The stability of ethyl alcohol was tested following the methods described by Guo et al. (1998), using alcoholic concentrations ranging from 56 to 86° Gay Lussac (GL) with 2°GL intervals. The lowest alcohol concentration in which there was instability and clot formation in the milk was considered as a positive result. On the day after the collection, the samples preserved by Azidiol® and Bronopol® were sent to the Laboratory of the Associação Paranaense de Criadores de Bovinos da Raça Holandesa (APCBRH) for the SPC, SCC, and milk composition analyses, using flow cytometry and infrared absorption techniques, respectively.

For the data analysis, the weighted means of the dairy farms was estimated. We used the analysis of each farm's cooling tank, weighted by the volume delivered by the farm to the dairy industry, which was added and divided by the volume of the compartment of the dairy transport truck. The data were submitted to ANOVA, using the MIXED procedure of the statistical package SAS® version 9.2 (Statistical Analysis Sofware [SAS], 2002). To obtain the normality of the residues, the psychrotrophic count, SPC and SCC were transformed into a logarithmic scale (log10), with normality being tested by the Kolmogorov-Smirnov test. For each dependent variable (milk quality indicator), the class effect was evaluated (weighted value of each dairy farm, the value measured in the truck, and value measured in the silo of the industry). The data were analyzed as a repeated measure of the collection day and the averages were compared by the Tukey test at the 5% significance level. To assess the relationship of milk quality indicators with hygienic-sanitary conditions of the milk storage room in the dairy farms and the milk transport trucks, the data were also evaluated by multivariate analysis technique (factor analysis) using the FACTOR procedure of the statistical package SAS®. The Promax rotation was used, with the data previously standardized by the STANDARD procedure. Factor loads ≥ 0.4 were considered significant.

Results and discussion

The period of milk collection between the first farm and the last farm, varied from 3.8 to 13.5 hours. However, the time from the first farm collected to the return of the milk truck to the dairy industry for unloading varied from 9.6 to 24.2 hours. Added with approximately 36 hours of milk storage on the farm, which is routinely done in the bulk milk tanks in the study region, raw materials were arriving at the dairy industry up to 60.2 hours after milking. The time difference between the end of the collection and the beginning of the unloading of milk on the dairy industry's receiving platform is because the company starts its activities at 1 am, and the trucks have their unloading scheduled from this time. Normative Instruction 77/2018 allows the time between milk collections in dairy farms to be up to 48 hours. These approaches optimize the storage capacity of the bulk tanks and reduce transport costs due to the greater volume of milk collected on the farm (Instrução Normativa nº 77, 2018). Nevertheless, article 27 of this normative disregard the time spent during transportation and does not impose any critical limits, which can significantly affect the quality of milk that arrives in the industry (França et al., 2015). Paludetti, Jordan, Kelly and Gleeson (2018) observed that, when stored at 4°C, the milk storage time limit until processing should be 48 hours.

Bulk transport and milk transfer to the industrial silo increased ($p < 0.0001$) the SPC and psychrotrophic counts (Table 1). In percentage terms and without logarithmic transformation, SPC increased 95% from the weighted count of the dairy farms (469,438 CFU mL^{-1}) and the dairy industry's amount (916,857 CFU mL^{-1}). Considering the average values of the storage silos (1,889,800 CFU mL^{-1}), the average total bacterial count increased 303% from the expected value for dairy farms. In all the evaluated points, the average SPC was above the maximum limits established by Normative Instruction 76/2018 (Instrução Normativa nº 76, 2018). Studies by Silva et al. (2009), Carmo et al. (2015), and Brasil et al. (2012) also found higher SPC values in milk stored in industry silos compared to the counts in isothermal tanks and bulk tanks in dairy farms.

Table 1. Least squares mean, standard error of the mean (SEM), and results of the variance analysis of the milk quality indicators for the weighted averages of the dairy farms, results measured at the truck bulk tanks, and the results measured at the dairy industries storage silos.

Variable	Dairy farms[1]	Tanks of the trucks[2]	Dairy industries' storage silos[3]	SEM	P-value
Psychrotrophic count (log10 CFU[4] Ml^{-1})	5.81^{c}	6.25^{b}	6.75^{a}	0.09794	< 0.0001
SPC[5] (log10 CFU mL^{-1})	5.60^{c}	5.91^{b}	6.25^{a}	0.06011	<0.0001
Milk temperature (°C)	3.98^{b}	6.22^{a}	2.52^{c}	0.3387	<0.0001
Acidity (°D)	15.39^{a}	15.66^{a}	15.81^{a}	0.2182	0.2974
pH	6.67^{a}	6.72^{a}	6.66^{a}	0.02498	0.1921
Alcohol (% v v^{-1})	73.76^{b}	75.60^{a}	75.04^{ab}	0.726	0.056
Fat (g $100g^{-1}$)	3.72^{a}	3.84^{a}	3.77^{a}	0.05539	0.2687
Protein (g $100g^{-1}$)	3.20^{a}	3.17^{a}	3.19^{a}	0.02497	0.4065
Lactose (g $100g^{-1}$)	4.27^{a}	4.25^{a}	4.27^{a}	0.01528	0.3915
TMS (g $100g^{-1}$)[6]	12.19^{a}	12.19^{a}	12.16^{a}	0.07109	0.7939
SNF (g $100g^{-1}$)[7]	8.40^{a}	8.35^{a}	8.39^{a}	0.02672	0.2477
SCC (log 10CS mL^{-1})[8]	5.83^{a}	5.89^{a}	5.88^{a}	0.03781	0.3031
Casein (g $100g^{-1}$)	2.44^{a}	2.45^{a}	2.47^{a}	0.02492	0.73287
MUN (g $100g^{-1}$)[9]	12.92^{a}	12.39^{a}	13.06^{a}	0.378433	0.1995

Values followed by different letters in the same column differ from each other by Tukey test ($p < 0.05$); 1= Values obtained from the dairy farms by the volume sold to the dairy industry. 2= Values obtained by the analyses of milk samples from each compartment of the truck. 3= Values obtained by the analyses of milk samples from the storage silo in the dairy industry. 4= Colony-forming units. 5= Standard plate count. 6= Total milk solids 7= Solids nonfat. 8= Somatic cell count. 9= Milk urea nitrogen.

The psychrotrophic count increased by 123 and 514%, from the weighted values of dairy farms (1.084.455 UFC mL^{-1}), to the results of the milk evaluated in the truck (2.419.844 UFC mL^{-1}) and of milk stored in the dairy industry silo (6.663.765 CFU mL^{-1}), respectively. Mörschbächer et al. (2017) and Paludetti et al. (2018) comparing the microbiological quality of milk before and after bulk transport also observed higher psychrotrophic counts in unloading the raw milk in the industry. The latest authors also concluded that the total bacterial count, psychrotrophic count, and proteolytic microorganisms increase after transferring milk to the storage silo. They impute this increase to the conditions of the pump and the filters of milk transferred from trucks to silo, to ineffective cleaning routine, and storage time or temperature that facilitate some bacterial strains. For psychrotrophic count, there are no limits defined in the Brazilian legislation. However, most studies in the area consider the count of 10^{6} CFU mL as a limit so that the deteriorating effects of these microorganisms' enzymes become significant (Cousin, 1982; Santana et al., 2001). Recent studies have already shown that counts above 5.0×10^{4} CFU mL^{-1} are already enough to observe an increase in proteolysis levels in raw milk in shorter periods, leading to sensory changes in milk (Vithanage et al., 2017; Santos et al., 2018). The development of microorganisms during transport is directly related to the storage temperature, route time, and initial milk contamination. Furthermore, the truck's hygiene condition is another fundamental point to be studied. In this regard, the connections and hoses become the most critical location (Silva et al., 2009). Chronic problems in cleaning equipment that have contact with milk can form biofilms, which become perennial sources of contamination of the raw material (Flach, Grzybowski, Toniazzo, & Corção, 2014).

The transport of raw milk in bulk, and the transfer and storage of the raw material for five hours in the industry silo did not influence SCS and milk composition (Table 1). Previous studies, such as those by Brasil et al. (2012) and Silva et al. (2009), also found that transport did not affect ($p > 0.05$) the SCS and compositional characteristics of the refrigerated raw milk received in the dairy industry. The physicochemical parameters of acidity and pH also remained constant in this study. The results of the alcohol test were within the minimum limits required by the legislation of 72% (Instrução Normativa nº 76, 2018; Instrução Normativa nº 77, 2018). Nevertheless, the values showed a tendency to improve the stability of the alcohol test ($p = 0.0560$) between the weighted results of the dairy farms, the measurement on the reception platform (unloading), and on the storage silo. This tendency may occur because the milk from the trucks and the storage silo went through intermittent agitation episodes, followed by long periods of rest, waiting for the pre-scheduled unloading time, and the start of processing. All of it can influence the results of milk stability on the alcohol test. Czerniewicz, Kruk and Kiełczewskal (2006) studied the effect of constant agitation of chilled milk, followed by different storage times and temperatures, and observed that the greater the agitation, the greater the concentration of ionic calcium in the milk and the lower its stability on the alcohol test.

There was a difference between the average milk temperatures (Table 1), with an average increase of 2.24°C between the dairy farm and the isothermal tanks of the trucks (moment of unloading) and a decrease of 1.46°C from the truck's tanks to the silo of the industry. The milk receiving temperature is within the limit recommended by IN 76, of 7.0°C (Instrução Normativa nº 76, 2018). Although, storage at 2°C is the limit in which there is a reduction in multiplication and, consequently, in the counts of proteolytic, psychrotrophic and thermoduric microorganisms and the control of potentially pathogenic and deteriorating bacteria (Vithanage et al., 2016, 2017). Unfortunately, due to the legally established temperature limit and the lack of equipment refrigeration with these technical specifications, maintaining the milk produced in Brazil at temperatures as low as those tested in studies by Vithanage and collaborators is not yet possible. Therefore, the main focus on the technical guidelines and measures taken by the dairy farms must be on the control/reduction of the initial contamination of the milk.

Several studies have already reinforced the importance of this theme and showed that storage under refrigeration and for shorter periods, is only efficient in maintaining the quality of milk and decreasing the levels of proteolysis in raw materials with low initial contamination, mainly by psychrotrophic strains (Reche et al., 2015; Ribeiro et al., 2018).

The factor analysis that evaluating the relationship among milk quality and hygiene in the storage room (where the bulk milk tank is), farm production, and milk storage temperature generated three factors (Table 2). The factors together explain 55.07% of the total variation. The communalities demonstrate the relevance of each variable used in this analysis. In factor 1, the psychrotrophic count and SPC showed a positive relationship between them, with a negative association with the cleanliness of the storage room and the bulk tank. With the relationships formed in factor 1, we can suggest that high SPC and psychrotrophic count are most common in milk from dairy farms with poor hygienic-sanitary conditions and poor structural conditions in the bulk tank storage room and in the bulk tank itself. Reche et al. (2015) found a strong influence ($p < 0.0001$) of the initial milk contamination on the total bacterial counts and psychrotrophic count. These authors reinforce the importance of good milk production practices by dairy farmers to obtain a product with satisfactory microbiological quality, which can be stored and transported and still reach desirable industrial processing characteristics.

Table 2. Factor loads, communalities, and percentage of the variance of each variable regarding the evaluation of the inter-relation of hygiene in the milk storage room and the bulk tank, farm production level, and milk storage temperature with the quality of milk collected by a dairy industry in the Vale do Itajaí Region.

Variables	Factors			Communalities
	Factor 1	Factor 2	Factor 3	
Psychrotrophic count (log10 CFU mL^{-1})[1]	0.78467	-0.21957	0.24344	52.96
Milk Volume (liters)[2]	-0.30753	-0.4764	0.12853	67.53
SPC (log10 CFU mL^{-1})[3]	0.78157	-0.0806	0.32409	56.92
Hygienic condition of the milk room[4]	-0.62067	-0.30053	0.32349	60.70
Hygienic conditions of the bulk milk tank[5]	-0.63912	-0.17229	0.28565	59.58
Milk temperature (ºC)[6]	-0.09536	0.43869	-0.22037	52.40
Fat (g $100g^{-1}$)	0.11432	0.69036	0.32938	62.39
Protein (g $100g^{-1}$)	-0.11252	0.80196	0.30999	55.17
Lactose (g $100g^{-1}$)	0.04784	-0.03254	-0.72215	51.97
SCS (log10Cel mL^{-1})[7]	0.02284	0.12972	0.6678	46.19
Variance percentage	24.92	15.59	14.56	

1 = Psychrotrophic microorganisms count from dairy farms milk samples. 2 = Milk volume collected in each dairy farm. 3= Standard plate count of milk samples from the dairy farms. 4= cleanliness and structure of the milk storage room, evaluated by a visual score from 1 (terrible) to 5 (excellent). 5= cleanliness of the bulk milk tank evaluated by a visual score from 1 (terrible) to 5 (excellent). 6= Milk temperature evaluated before loading into the transport truck. 7= Somatic cell score from milk from dairy farms milk samples.

In factor 2 (Table 2), the variable milk volume had an opposite relation to protein and fat levels and milk temperature. The lower the milk volume, the higher the solids contents and the milk temperature. Smaller dairy farms, and, usually, with lower cow productivity, produce milk with higher solids content (Voges et al., 2018). Nevertheless, these farms have refrigeration equipment that is less efficient in maintaining the milk's temperature. The third factor showed the inverse relationship between SCS and lactose content (Table 2). As in the present study, Alessio et al. (2016) found that cows with higher SCS have lower milk lactose levels. Possible explanations for this reduction include damage of the secretory cell, increased permeability of the alveolar epithelium, and the use of lactose by pathogens (Santos & Fonseca, 2019).

The second factor analysis evaluated the relationship between the bulk transport of raw milk and the quality of milk received by the industry. The three dimensions formed, explain the 78.42% of the total variation (Table 3). The first factor had the truck cleaning variables (external, compartments, connection, and hose) with the highest factorial loads and, positively correlated. These variables showed an opposite relationship with the percentage increase in psychrotrophic count during milk transport. The results presented in factor 2 reinforce the association found in factor 1, in which we observed a positive association between the time from the milk collection at the first dairy farm of the truck route, the percentage increase in the psychrotrophic count, and the percentage increase in the SPC.

We observed the inverse relation with the truck bulk milk compartment's cleanliness and the truck connection cleanliness (made the connection of the truck to the bulk milk tank in the farms) with worst hygiene conditions. The inverse relationship between cleaning variables and the psychrotrophic count and SPC in milk demonstrates the importance of cleaning trucks, mainly due to the possible biofilm formation (Nörnberg et al., 2009). Flach et al. (2014) evaluated the formation of biofilms in storage tanks and observed that 50.2% of isolated psychrotrophic bacteria presented the ability to adhere to form biofilms.

Table 3. Factor loads, communalities, and percentage of the variance of each variable regarding the evaluation of the inter-relation between the bulk milk transport and milk quality.

Variables	Factors			Communalities
	Factor 1	Factor 2	Factor 3	
Percentage increase of psychrotrophic count (log10 UFC mL^{-1})[1]	-0.44611	0.43628	0.27977	57.17
Percentage increase of SPC (log10 UFC mL^{-1})[2]	0.28175	0.51689	0.53779	61.79
Truck route time (hours)[3]	0.00645	0.92992	0.05893	87.42
Truck outside cleanliness	0.97778	0.12339	-0.01831	91.60
Truck milk compartment cleanliness	0.63931	-0.47563	0.29326	84.19
Truck connection cleanliness	0.71583	-0.34211	0.06059	74.20
Truck milk hose cleanliness	0.95973	0.14887	-0.19545	90.69
Milk temperature at the receiving platform[4]	-0.18500	0.00025	0.87982	80.39
Variance percentage	45.38	20.27	12.77	

1 = Percentage increase of psychrotrophic count during the transport, from the weighted means of dairy farms samples and the sample analyses' values. 2= Percentage increase of standard plate count during the transport, from the weighted means of dairy farms samples and the values obtained by the sample analyses. 3= time between the milk collection at the first dairy farm of the truck route until the return to the dairy industry to unloading. 4= Milk temperature at the milk receiving platform of the dairy industry. *= Cleanliness scores performed by visual evaluations from 1 (terrible) to 5 (excellent) points.

Factor 3 shows the positive relationship between percentage increases in SPC and higher milk temperature at the industry's receiving platform. The association between the increase in milk temperature and the increase in SPC is possibly related to milk with higher temperature favors the multiplication of microorganisms, mainly mesophilic. Izidoro, Pereira, Soares, Spina and Pinto (2013) observed that the SPC increased as the temperature and storage time increased in milk stored at different temperatures. The factors formed shown that basic actions such as the proper planning of the collection and transport routes for milk, with shorter and faster routes, good practices in primary production, and technical guidance for the dairy farmers and transporters are essential for good milk quality. So, the final dairy product that reaches the consumers will be safe and maintains the nutritional and organoleptic quality. These findings reinforce the importance of the rules established in the current normative of milk quality, showing the importance of a rigorous selection of raw material suppliers and obliging the dairy industry to provide, in their self-control programs, the qualification plans of these suppliers. These self-control programs must include technical assistance and management to training, focusing on farm management and the implementation of good production practices. Nevertheless, we still need regulations that provide limits on the psychrotrophic count and strict rules for bulk milk transport, especially concerning the time and temperature binomials that minimize the development of this class of microorganisms and, consequently, the negative effects on the final product and possible economic losses.

Conclusion

The transportation of raw milk in bulk trucks and its transfer to the storage silo in the dairy industry worsens the milk's microbiological quality, both concerning PMC and SPC, without altering the milk composition, SCC and physicochemical parameters from samples collected from dairy farms.

The adverse effects of milk transportation can be minimized by the trucks' adequate hygiene, changes in transport logistics, reducing the size of the routes and the transportation time. Milk with better microbiological quality, even for low PMC, is obtained in farms that have a properly structured storage room and a bulk tank in good hygienic-sanitary conditions.

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