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Original article

Evaluation of the Hygienic Quality of Raw Milk at Different Levels of the Dairy Chain[1]

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Abstract

Variations in the hygienic quality of raw milk collected at different levels of the dairy chain from the farm, tanks, at the end of collection and at delivery in the north-central region of Algeria were studied over a period of one year. The average loads of all the germs of contamination increased gradually ($p<0.001$). The average values of these respective evolutions of the farm, at the end of collection and delivery, expressed in Log10 cfu/ml of raw milk for total aerobic mesophilic flora (TAMF), total and faecal coliforms (TC), (FC) values are (5.11, 6.42 and 7.5), (3.1, 4.6 and 5.31), (1.61, 3.29 and 4.29). Yeasts and molds are present with high levels of contamination in the samples analyzed, the average per milliliter expressed in Log10 cfu at each collection site are respectively (2.84, 4.58 and 5.34), (1 24, 3.23 and 3.88). The pathogenic flora also has increasing presence rates at each level of the dairy chain. Milks from farms that were already contaminated with Clostridium, Listeria monocytogenes, and Staphylococcus aureus (15.27, 1.39 and 4.86%), respectively, arrived at the different dairies with exponential mean presence (50; 28.33 and 56.66%). However, it should be noted that the danger is all the more important as the presence rate and the microbial load are higher in raw milks. The strong growth of the micro-organisms studied once again demonstrates the variability of practices from one sampling site to another. This is the result of poor hygienic conditions during milking, they also provide information on the degree of handling of milk, including the observed transvasions.

Keywords: Hygienic quality, Raw milk, Farm, Collection, Delivery.

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INTRODUCTION

Algeria, like other developing countries, pays particular attention to the livestock sector and more particularly to dairy production as part of its strategic plan to revive its economy. The main objective is to develop local milk production in order to improve the self-sufficiency rate in consumer products and decrease the dependence in the dairy sector. The milk production in Algeria has increased significantly since it has almost tripled in 20 years to reach 3.6 billion liters in 2016 (MADR, 2017). Despite this increase, it does not cover the needs of the population evaluated at 5.5 billion liters per year, given the increase in demand. In fact, only 35% of this raw milk production is collected for the industry in 2016. In order to encourage farmers to deliver their milk, the dairies collect all the milk whatever its hygienic or nutritional quality and controls are intended only to avoid anchoring. In addition to the low level of domestic milk production, the quality of this commodity remains equally worrying (Kaouche et al., 2014a; Kaouche et Mati, 2017). It is in this context that the objective of this study is to assess the hygienic value of raw milk throughout the dairy chain from production on the farm to delivery to the dairy.

Material and Methods

Material

Areas and Study Population.

Our study identified five areas of the mid-northern region of Algeria (Algiers, Blida, Bouira, Boumerdes, and Tizi Ouzou). It included twelve exploitations, three dairies and five collection trucks, each equipped with an insulated tank and a pumping system. The selection criteria are based primarily on their location in the study region, as well as their acceptance to cooperate in this work.

Survey of the Situation

A survey was performed to collect information about the farms, the various collectors, and dairies in order to characterize each link in the chain of milk production.

Methods

Sampling Protocol.

The study was conducted on a total of 264 samples: 144 samples were collected at farm level (96 from milk tanks and 48 from buckets), 120 samples were collected at two levels in the sector: 60 from the collector's tank at the end of the collection (M1) and 60 taken from the same tanks at delivery (M2). All samples correspond to the morning milking. About 100 ml was taken aseptically in sterile test tubes from each level for microbiological analysis. All samples were stored at temperatures between 4 and 8°C in a cold box and transported to be analyzed immediately after arrival to the laboratory.

Physical analysis

The milk temperature is measured at each level of the die (on the farm, in the tank before its departure and on arrival at the dairy plant) using a thermometer.

Microbiological Analysis

In each sample, 9 microbial groups were counted. They were studied by conventional cultural methods of enumeration and isolation on specific culture media or enrichment: Total aerobic mesophilic flora (IDF, 1991), coliforms (IDF, 1974), yeasts and molds (NF ISO,7954,1987), *Staphylococcus aureus* (NF V08-057-1, 2004), *Salmonella spp*. (ISO 6579, 1990), Clostridium sulphito-reducers (Harrigan and Mac Cance, 1976), *Listeria monocytogenes* (ISO, 2004) and antibiotic residues by the Delvotest® method (EU, 1990). The germ count was performed on box using a counting colonies (Colony Counter; SC6 +, Bibby Scientific Ltd, United Kingdom). For each sample, 1 ml of milk was added to a sterile test tube containing 9 ml of sterile physiological saline. Were carried decimal dilutions to 10^{-6}.

Statistical Analysis

The results of microbiological analyses were transformed into Log10 cfu/ml to achieve parametric statistical tests. Data were analyzed using ANOVA with the following modules of STATISTICA 8.0. The significance level was fixed at < 0.05.

Results and Discussion

The analysis of the results of the present study indicates that the measurement of the temperature as shown in figure 1, knows significant changes ($p < 0.001$) between the different levels of sampling. The average high temperatures at the production sites (11.2 °C) would probably be due to the introduction of hot milk each time into the tank or into the bucket. They are also the result of the lack of means of conservation and cooling of milk in the third of the farms. While lower temperatures in the milk tank at the end of collection (10.3 °C) and those of the delivery (8.8 °C) are mainly due to the progressive cooling of the milk in the tank.

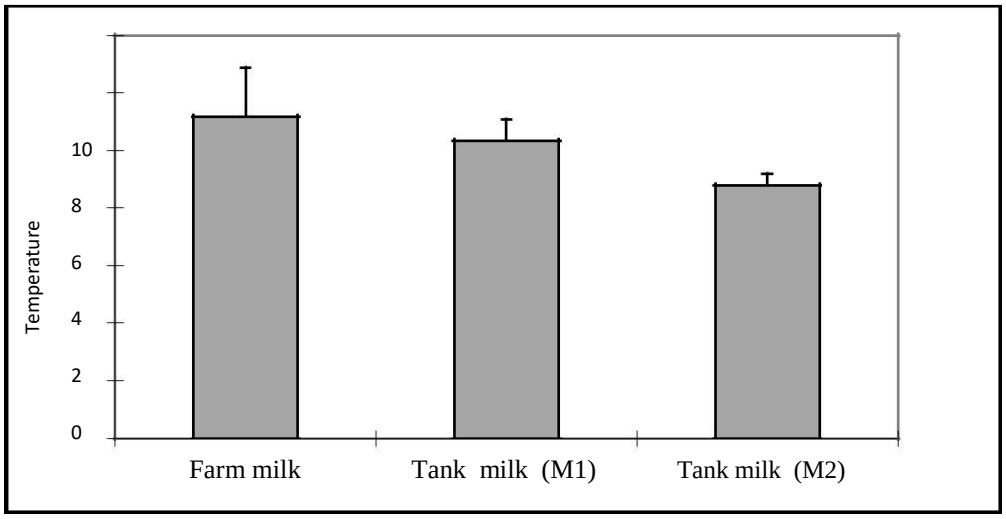

Figure 1. Mean evolutions temperature of milk from the production sites to the dairies.

The average temperature of the milk samples collected at different levels of the dairy sector do not meet international standards of between 4 and 8°C. Whereas according to J.O.R.A (1993), the Algerian standards require storage temperatures farm ≤6°C. These temperature values are lower than those found by Gran et al. (2002) between the farm and the point of sale in Zimbabwe (32.6 and 24.4°C) and Bonfoh et al. (2003), between 27.1 and 31.4°C in Mali. According to Pistocchini et al. (2009), a high temperature in delivery increases the number of microorganisms in milk. The quality of the latter is influenced by storage and transport parameters. An elevated temperature (+ 8°C) promotes the growth of lactic acid bacteria, where the acidification of milk, in particular if this temperature is associated with inappropriate transportation conditions (Kaouche et al., 2014a). The average loads of all the desired germs of contamination have greatly increased gradually from farms to the point of sale (figure 2). These variations are very significant from one sampling level to another ($p < 0.001$). The average values of the respective changes in the farm, at the end of the collection and delivery, expressed in Log10 cfu/ml of raw milk for TAMF, TC and FC are (5.11; 6.42 and 7.5), (3.1; 4.6 and 5.31), (1.61; 3.29 and 4.29). Yeasts and molds are present with high levels of contamination in the samples analyzed, the average per milliliter expressed in Log10 cfu at each collection site are respectively: (2.84; 4.58 and 5.34), (1.24; 3.23 and 3.88). These germs are the permanent elements of the environment, they are the result of poor hygienic conditions during milking, they also provide information on the degree of manipulation of milk, including transfers found on all farms except in a single unit that practice milking in a milking parlor where milk is not handled. However, it should be noted that this strong growth of the studied germs and the important dispersion of the results around the average, testify once more of the variability of the practices from one sampling site to another. According to El Moslemany et al. (2010), the levels and types of microorganisms in the refrigeration tank provide information on hygiene conditions during various stages of on-farm dairy production.

The handling of milk from the site of its production until its reception at the level of the dairy could be one of the factors causing the heavy loads in yeasts and molds in our study. The contaminations are more important for these two germs as well in hot season as in cold season.

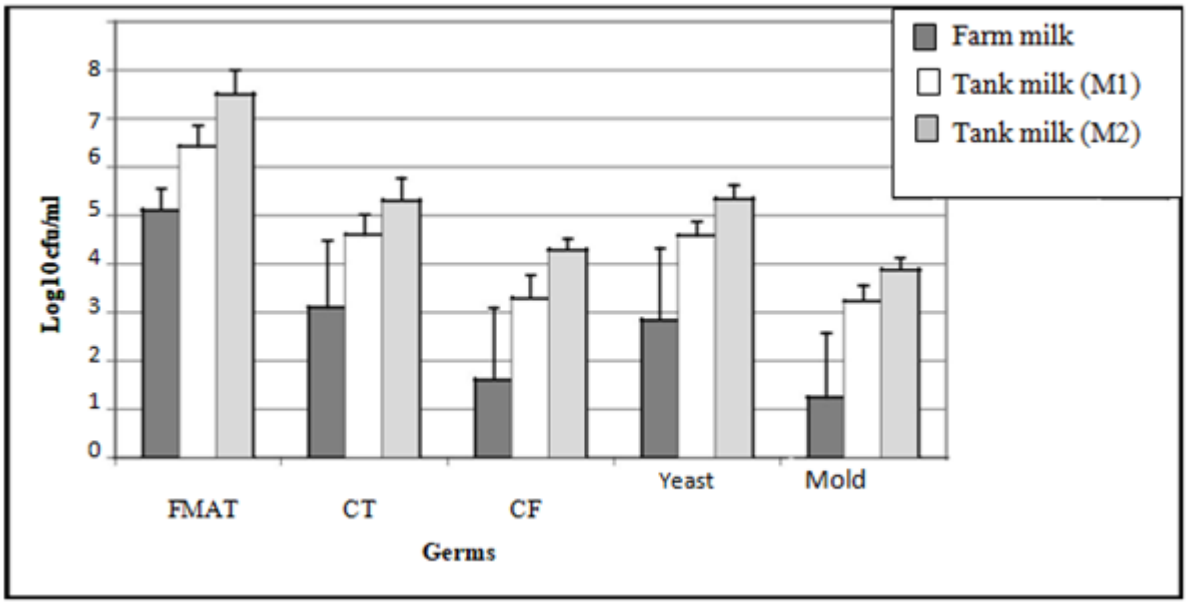

Figure 2. Evolutions of the average loads in contamination germs of milks from the production sites to the dairies.

The diversity of the microbial composition of raw milks analyzed is considerable and depends on factors of production, more particularly on practices surrounding milking (Kaouche et al., 2014a; Kaouche and Mati, 2017). All search contamination germs are correlated with all the hygiene practices considered: the practice of cleaning the udder ($p<0.05$), the cleanliness of the barn ($p<0.001$), the cleanliness of the milking machine ($p<0.005$) and litter ($p<0.001$). The practice of milk mixing from different dairy barns ($p<0.001$), storage and transport conditions ($p<0.05$), antibiotic residues and the distance traveled by the collector to the dairy plant ($p<0.05$). A significant development of TMAF and mold in this study is attributed to the degree of cleanliness of the milking machine with respectively $p<0.001$ for TMAF and $p <0.05$ for molds. The pathogenic flora shown in figure 3 also has increasing presence rates at each level of the dairy chain.

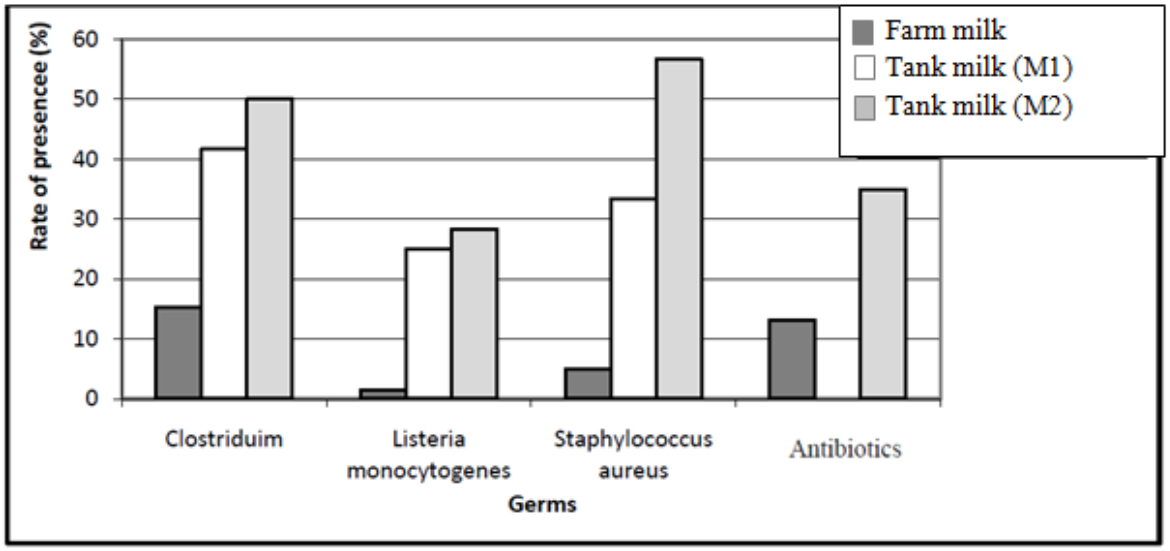

Figure 3. Evolutions of the presence rates of pathogenic bacteria and antibiotics in milk production sites to dairies.

Milks from farms wich that were already contaminated with Clostridium, *Listeria monocytogenes*, and *Staphylococcus aureus* (15.27; 1.39 and 4.86%), respectively, arrived at the different dairies with exponential mean presence ratios (50; 28.33 and 56.66%). The results of the analyzes conducted in our study for *Salmonella spp*, showed no contamination at all levels of the analyzes performed.

However, it must be emphazised that the danger is all the more important as the presence rate and the microbial load are higher in raw milks. Indeed, the high temperatures also favor the growth of certain pathogenic bacteria such as *Staphylococcus aureus*, *Salmonella spp*, *Listeria monocytogenes*, *Escherichia coli* and Clostridia (Mellenberger and Kirk, 2001). Similarly, antibiotic residues detected in 13.2% and 35% of farm samples respectively and at admission to dairies are the result of mixtures of milk from different farms. Their presence reflects the fact that the regulatory waiting times are not applied by some breeders in our study sample, either for fear of reduced quantities of milk sold and it reduced income, or because of lack of knowledge, lack of awareness. Knowing that controls the sale does not take into account these residues to sanction the producer.

The relationship is also established in this study between the pathogenic germs present in raw milk samples from farms analyzed and the high temperatures recorded when they are>9°C with $p<0.05$. According to Chye et al. (2004), contamination of the udder, milking utensils or water used can induce a high count of coliform bacteria associated with the presence of pathogens in the milk.

The traditional milking practices identified in this study were also described by LUES et al. (2010) in the South African peri-urban zone and Belli et al (2013) in Cameroon, to be likely to contribute to the faecal contamination of animals milk and the proliferation of several microorganisms. These results are

in agreement with the data of the bibliography (Cempirkova, 2006; Grimaud et al., 2007; Millogo et al., 2010; Kaouche et al., 2014a; Kaouche and Mati, 2017), which have already confirmed that utensils used for milk collection are generally the largest source of milk contamination.

However, microbial contamination in raw milk before it leaves the farm, not only depends on its contamination during milking and storage conditions, but also the temperature at which it was stored (Soler et al., 1995). Nevertheless, the method of delivery associated with the collection system found in this work allows the mixing of milk from different dairy barns. Then, it would be enough that the milk of a single farm is not well preserved and therefore presents a poor hygienic quality so that all the milk of this same tank is deteriorated.

This would favor the growth and multiplication of existing micro-organisms, at higher or lower rates. Microbial contamination in raw milk depends according to Soler et al. (1995) of the time elapsing between the milking and collecting. The Algerian standard (J.O.R.A, 1993) sets a maximum of 48 hours between milking and the delivery of milk to dairies. However, transport conditions have been reported to have contributed to the poor hygienic quality of milk in the studies conducted in Addis Ababa by (Godefay and Molla, 2000) and in the northern mid-region of Algeria (Kaouche et al., 2014a). The results also indicate that the germ count averages studied in the samples on delivery are significantly higher than those of milk collected before departure, at the end of the collection. Moreover, Bouzaid et al. (2012) in Morocco reported average values per milliliter in TMAF, TC and FC of ($4.4.10^{7}$ufc, $3.8.10^{5}$ufc and $1.91.10^{5}$ufc), on the raw milk sampled from the point of sale. Their results are superior to ours, obtained on delivery ($3.2.10^{7}$ cfu / ml = Anti 7.5 Log10 TMAF and $2.1.10^{5}$ cfu/ml = Anti 5.31 Log10 CT and 2.10^{4} cfu / ml = Anti 4.29 Log10 FC). The storage and transport temperature gives the bacteria the ability to adapt and grow in this highly nutritious liquid (Semereab and Molla, 2001). It should be noted that the transport factor was closely related ($p<0.05$), with the development and proliferation of the pathogenic microflora mainly, in the study conducted by Kaouche et al. (2014b). However, the distance traveled by the collector to the dairy plant and average counts in various germs are determined to be strongly associated ($p<0.05$) at the delivery.

These observations are in perfect agreement with the results of Gran et al. (2002). The level of microorganisms in the milk on delivery is likely to increase with increasing delivery time. Deterioration will only be minimized if the milk reaches the dairy during the lag phase of bacterial multiplication, generally considered around 3 hours after milking (IDF, 1990). In the study of Belli et *al* (2013), in Cameroon, a large percentage (87.1%) of the delivery samples showed coliform levels below the threshold. But positive samples for this germ showed a high level of contamination (>5 log cfu / ml), mainly related to the means of transport and the distance traveled by the collector.

Conclusion

The results of the physical and microbiological analyzes carried out in the context of this study have revealed the deterioration from one level to another of the hygienic quality of raw milk produced on farms of the north-central region of Algeria closely related to all hygiene practices considered. The main cause is the lack of hygiene and sanitation at the various links in the chain. The risks are serious for consumers in the absence of regulations and control structures throughout the dairy chain in order to ensure a better hygienic quality of the dairy products.

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