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TYPIFICATION OF FACTORS RELATED TO MILK PRODUCTION AND ITS IMPACT ON THE SANITARY QUALITY OF MILK

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ABSTRACT - Aiming at identifying and characterizing the dairy production systems regarding the hygienic and sanitary practices in milking on the sanitary quality of milk, 32 properties were analyzed through the data collection by means of a semi-structured questionnaire. The collected data were analyzed by multivariate statistical analysis, using the Principal Component Analysis (PCA) and analysis of Ascending Hierarchical Classification - Cluster (CHA). Firstly, a cluster analysis was used for forming groups of variables. Through the groups formed was sought to obtain the explanatory variables through the PCA. Three PCA were obtained, which were named according to the variables of greatest effect in the analysis. The groups were called PCA-1: Equipment and contamination; PCA-2: Milking Technology; PCA-3: Scale of production. These results enabled the representation of the different characteristics of the production systems through cluster analysis, where for each PCA was performed a Cluster analysis, always with five groups of dairy production systems being formed with similar characteristics within each group. The formation of the groups enabled to identify that the performance of techniques and hygienic-sanitary managements of milking is more related to the age and producer's education, linked to time in the dairy business.
Key words: PCA, hygiene, milk.

TIPIFICAÇÃO DE FATORES RELACIONADOS À PRODUÇÃO LEITEIRA E SEU IMPACTO SOBRE A QUALIDADE SANITÁRIA DO LEITE

RESUMO - Com o objetivo de identificar e caracterizar os sistemas de produção leiteira em relação à higiene e práticas sanitárias na ordenha sobre a qualidade sanitária do leite, 32 propriedades foram analisadas por meio da coleta de dados utilizando questionário semi-estruturado. Os dados coletados foram analisados por meio de análise estatística multivariada, usando a Análise de Componentes Principais (PCA) e análise de Classificação Hierárquica Ascendente - Cluster (CHA). Primeiramente, a análise de agrupamento foi utilizada para a formação de grupos de variáveis. Através dos grupos formados procurou-se obter as variáveis explicativas através do PCA. Três PCA foram obtidos, os quais foram designados de acordo com as variáveis de maior efeito na análise. Os grupos foram chamados PCA-1: Equipamentos e contaminação; PCA-2: Ordenha Tecnologia; PCA-3: escala de produção. Estes resultados permitiram a representação das diferentes características dos sistemas de produção por meio da análise de cluster, onde para cada PCA foi realizada uma análise de cluster, sempre com cinco grupos de sistemas de produção de leite formados com características semelhantes dentro de cada grupo. A formação dos grupos permitiu identificar que o uso de técnicas higiênico-sanitárias de ordenha está relacionado com a idade e escolaridade do produtor, ligado ao tempo na atividade leiteira.
Palavras-chave: PCA, higiene, leite.

INTRODUCTION

Milk quality is assessed according to the hygienic and sanitary aspects, such as total bacterial count (TBC) and somatic cells count (SCC), as well as its composition. Moreover, milk is one of the results (the main one in many cases) of a fairly complex production system, according to type (HOUSTIOU, 2006); diverse, regarding the set of systems (DAMASCENO et al., 2008) and inclusive,

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regarding its quantitative representation in the state of Paraná, which currently exceed 114,400 producers (IPARDES, 2009). Thus, the results obtained in dairy farms are constructed from animal performance associated with man-made sporadic or daily practices (CHEVEREAU, 2004).

The milk quality, however, suffers large variation between farms because each property has unique characteristics for milking, nutritional and health management, which directly reflect the composition and milk quality (CUNHA et al., 2008). Among the many factors affecting the milk quality, there are extrinsic factors such as environmental hygiene, temperature of stored milk, milking hygiene practices, surface microbiological analysis and water quality used for washing the milking equipment (BERRY et al., 2006).

Thus, the knowledge of factors affecting the milk quality produced on the farm allows the milk producer act or not on them, manipulating those factors that can be changed. This will enable the adoption of control measures that improve the microbiological quality of the milk, adapting it to the standards established initially by the IN 51 (BRASIL, 2002), and currently redefined by the IN 62 (BRASIL, 2011).

In the analysis of production systems is elected the principal component analysis (PCA) for its ability to synthesize large data tables and indicate the variables responsible for the production systems diversity (MBURU et al., 2007; SMITH et al., 2002). The proposed typology aims at characterizing homogeneous groups of dairy systems in order to make the compatible action according to their specificities (BODENMÜLLER FILHO et al., 2010).

Thus, the study was conducted in order to typify the dairy production systems, characterizing them by the practices and techniques used in the milking management and its effects on milk quality.

MATERIAL AND METHODS

The study was conducted in Dairy Production Systems (DPS) belonging to the city of Toledo, in Paraná State-Brazil. Along with the study, there was the partnership with a dairy belonging to the same city, where such properties provided their production, i.e. the raw material: milk. 32 properties were sampled, representing approximately 30% of the properties that make the delivery of their production to the dairy. Data from this study were obtained through questionnaires made directly to producers, milk analysis of these properties and information reported by the dairy.

The questionnaire, in turn formulated, also called 'semi-structured guide questionnaire', was based on studies conducted in research and data collection in Dairy Production Systems (DPS), which researchers in the field of milk production chain have formulated, adapted and used (DAMASCENO et al., 2008; DEDIEU et al., 1997; SOLANO et al., 2000).

For milk quality were analyzed the somatic cells count (SCC), the Total Bacterial Count (TBC) and thermotolerant coliforms count. Also, it was analyzed the count of total coliforms present in water used on the farm. For each milk and water variables analyzed, there was a collection for the summer season and other for the winter. For the analyses of milk samples, the procedure was based on milk collection aseptically in sterile vials of 100 ml. After samples collection, they were packed in insulated box containing ice at ± 7 ºC and sent for analysis to the Laboratory of Milk Quality Control (RBQL), the Paraná Association of Breeders of Holstein Breed, located in the city of Curitiba - PR. The samples were analyzed using the Bactocount 150 (BENTLEY INSTRUMENTS, 2004) and Somacount 300 (BENTLEY INSTRUMENTS, 1995) for determining the TBC and SCC, respectively. In one of the milk samplings for TBC was verified the total count of mesophilic aerobic, using the PetrifilmTM AM plate according to the AOAC 991.14 Official Method (AOAC, 1995).

For the analysis of total coliforms in water and thermotolerant coliforms in milk, the samples were sent to the laboratory of Microbiology and Biochemistry from the State University of West Paraná - Campus Marechal Cândido Rondon. Coliform Count was performed using a PetrifilmTM CC Plate and the thermotolerant coliforms count was performed using a PetrifilmTM EC plate according to the AOAC 991.14 Official Method (AOAC, 1995), following the time and temperature of incubation according to the method and calculated the number of colony forming units (CFU) according to the dilution used.

After the questionnaire, data were analyzed by means of multivariate analysis, being used the models of Principal Component Analysis (PCA) and Ascendant Hierarchical Classification (CHA), and later being made the typology through cluster analysis.

It was proposed an analysis methodology different than what is normally used. First, it was conducted a PCA and later a CHA analysis of all the variables together, making up the typology. This procedure was performed in order to determine which variables would have greater effect on the study, and also group the variables into n groups characteristic among themselves. After having characterized the groups, they were named, and the denomination was determined according to the presence of these variables within each group.

For each group formed was performed a PCA and CHA analysis for subsequent observation of which variables exerted a greater effect on the group, and typologies formation of the SPL similar among each other. The groups of dairy farms formed were distinguished according to the variables characteristics, each group being called a separate system. The application of multivariate statistical models in this study aimed at stratifying dairy farms in homogeneous groups and differentiated among themselves, whose production techniques in combination represent distinct production systems. The variables were processed using the SPSS® version 18.0 (2010), allowing the identification of the principal components and the accomplishment of the cluster analysis.

RESULTS AND DISCUSSION

The contributions of the first two principal components of the factorial analysis of PCA-1 (Equipment and contamination) (Figure 1) determined that the first principal component (Dimension 1) explains 23.24% of the variance and the second (Dimension 2) explains 17.10%, totaling 40.34% for the first two components.

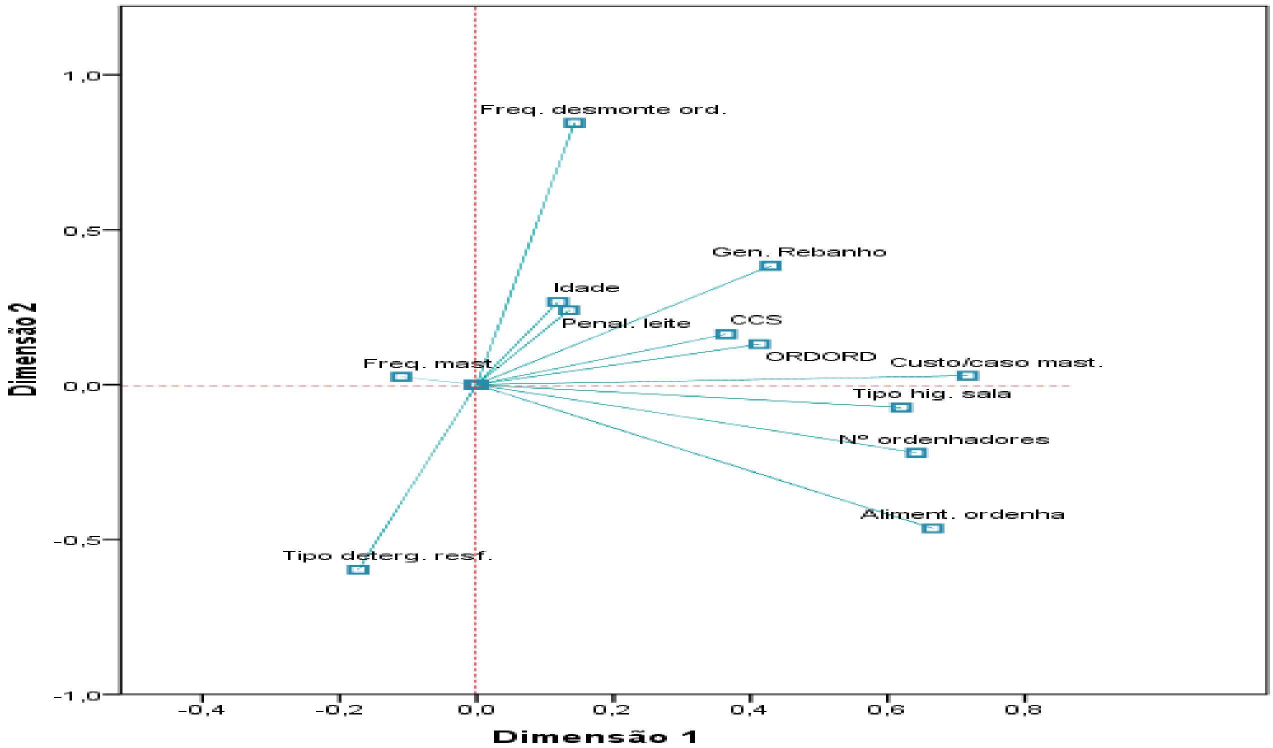

FIGURE 1 - Representation of the components of the factorial analysis of PCA-1 (Equipment and contamination).

The principal component 1 was characterized as mastitis practice. The variables that characterized the positive side were those related to the cost per case of mastitis, milking order accomplishment and sanitization of the milking parlor, and the negative was the frequency of occurrence of mastitis cases. The principal component 2 was characterized by the hygiene practices in milking set cluster and storage tank. For the positive side, the component was characterized by the variable dismantling of the milking set and for the negative side, the use of detergent in the storage tank sanitation.

The frequency of occurrence of mastitis was related to the type of applied hygiene in the milking parlor, the number of milkers in the management and the food supply to the animals during milking. Regarding the cleaning of the milking parlor, it was observed that when water was used with pressure combined with detergent for sanitation, the occurrences of mastitis were lower, different from when only water was used for cleaning.

With respect to the physical structure of the properties, Monteiro et al. (2007) found that the majority had conditions considered as disabled without basic facilities or poorly planned facilities, often stables that generated great difficulties for cleaning.

The number of mastitis cases was lower when the number of milkers was higher. The higher number of milkers can be related to the higher amount of people available during milking; both to perform the tests for mastitis detection and to conduct a hygienic-sanitary management of correct milking (teats washing, pre-dipping, complete milking, post-dipping). The food provision during milking proved to be a management that increased the frequency of mastitis cases, it being possible that animals would be stimulated to perform milking or rather, that milk letdown occurs only when they were fed.

SCC was influenced by the completion of milking management order, i.e. when performing this practice on the property the SCC values were lower. The completion of milking management order and correctly allows at least two advantages: primarily maintaining the milk quality, discarding milk from animals with mastitis or when any drugs had been used so that milk cannot be sold; the second advantage would be preventing the direct transmission of microorganisms causing mastitis, since these animals are milked last.

According to Fagan et al. (2008), variations of somatic cells in milk, in both studied farms estimated by the CMT and quantified by SCC, were mainly the deficiencies in milking management practices and, the number and lactating phase of the milked animals. The completion of the dismantling of the milking set was influenced by producer age, where older producers performed the set dismantling more often. In contrast, younger producers did not perform dismantling. However, they made the use of these specific detergents such as alkaline and acid, and/or sanitizing for cleaning the cooling tank, which in properties with older producers was performed with neutral detergent. The completion of milking set dismantling, as well as the use of detergents in washing tank, are forms of hygiene in order to decrease the TBC and thus maintaining the milk quality.

For the analysis of typologies were formed five groups. The distribution of groups of properties relating to the PCA-1 (equipment and contamination) can be observed in Figure 1. Group 1 was formed by systems 1 and 14 and was characterized by the high cost per treated mastitis case, exceeding the value of R$ 1000.00. In this case, it is defined that these properties not only take into account the expenses with drugs (antibiotics), but also the costs of disposing milk and animal productivity losses during lactation.

Monteiro et al. (2007) found that only 16 producers (39.0%) claimed performing treatment of mastitis in lactating animals, whereas 09 (56.3%) performed the milk discard only for rooms under treatment, 06 (37.5%) discerded all milk and only 01 (6.3%) affirmed not discarding the milk even from rooms treated with antibiotics.

Group 2 was represented by 26 systems and was characterized by herd genetics being returned to the milk production. The selection of animals for higher milk production can result in decreased reproductive efficiency, as well as increased health problems, which include the higher incidence of mastitis cases. Thus, an animal with large production requires greater care compared to those of small production. The system 3 is the Group 3, characterized by the low producer age, but with frequent problems of mastitis in the herd. This problem with mastitis can be related to the lack of experience of producers, since they are younger and possibly in the dairy business recently.

According to Coentrão et al. (2008), the second highest risk for occurrence of subclinical mastitis was the lack of training programs for hand labor to perform the milking. In properties where employees did not receive any kind of training, such as explanations of appropriate procedures during milking, use and maintenance of milking equipment, examination of the first milk streams in all rooms or CMT completion (California Mastitis Test), the animals showed 2.51 more times of chances to present SCC above 200,000 cells/ml.

Group 4 was formed by systems 6 and 28, being characterized by non-realization of the dismantling of milking set for cleaning. The completion of the milking set dismantling for hygiene is a practice recommended to improve the efficiency in the cleaning of equipment; however, this practice is optional in the properties, being carried out on its own producer.

In the study by Miller et al. (2007), regarding cleaning the milking equipment, was found that the swabs made in the pipes connections showed that the quantity of microorganisms is much higher at the points where there are bends.

The system 13 represented the Group 5 and was characterized by the implementation of proper hygiene practices in the storage tank and milking parlor, completion of the milking set dismantling and performing milking order management correctly. Thus, this property can be defined as reference, being standard compared to the hygiene managements employed.

The representation of the Principal Components Analysis 2 (PCA-2), as its typology for the 32 SPL, can be observed in Figure 2. The PCA-2 was characterized as "Milking Technology", being its variables related to milking management practices.

The contributions of the first two principal components of the factorial analysis of PCA-2 (Milking Technology) determined that the first principal component (Dimension 1) explains 25.27% of the variance and the second (Dimension 2) explains 16.04%, totaling 41.31% for first two components.

The principal component 1 was characterized as practices to TBC decrease. To the positive side, this was influenced by the milking practices related to producer’s education. To the negative side the influence variables were TBC and length of service, and to a lesser extent the presence of coliforms in water. Component 2 was characterized by hygiene practices. For the positive side the discarding practices for the first three jets, and to the negative side, the use of hot water in the cooling tank cleaning. However, these practices also assist in reducing the TBC. The TBC was mainly related to the producer’s education, and the TBC was lower as higher the producer’s education level.

Education was important in reducing the TBC because it was related to practices and techniques used in milking and cows management, the practices having compliance as the higher the producer’s education level. Thus, the practices related included the use of uniform in milking and detergents to clean the equipment, completion of the milking order, and disposal management of cows with mastitis.

Thus, it is observed that producers who have greater knowledge, or seeking more information about the dairy business itself and practices used, excel over other producers in relation to hygiene factors. Furthermore, it was observed that these producers were still more accessible to the use and utilization of products and/or practices to decrease the TBC.

By the factorial plan, it could also be observed that the TBC is influenced by the presence of total coliforms in the water, whose higher coliform counts reflect greater TBC. Thus, use of high quality water for cleaning the teats and milking equipment is extremely important to maintain the milk quality.

The water is very important in milk production chain, it is important that its origin offers quality for use in dairy farming (POLEGATO; AMARAL, 2005), or some treatment provides it such quality. Moreover, it was observed with respect to time in the activity that it may be responsible for the increased TBC. Not that the time in the activity is a direct factor increasing the TBC, but it influences the decisions made by the producer. However, the factor time in the activity is directly related to the producer age. Therefore, older producers are more restricted to the use of new technologies, more modern practices and/or use of products to maintain the milk quality.

Thus, it was found that time in the activity mainly influenced practices used for milking, these being practices use of products for pre and post-dipping and tests for mastitis detection. Regarding the use of pre and post-dipping, this was performed in the time in the activity was lower. Likewise, regarding the mastitis tests, i.e. they were performed and more frequently in properties that recently started in dairy farming.

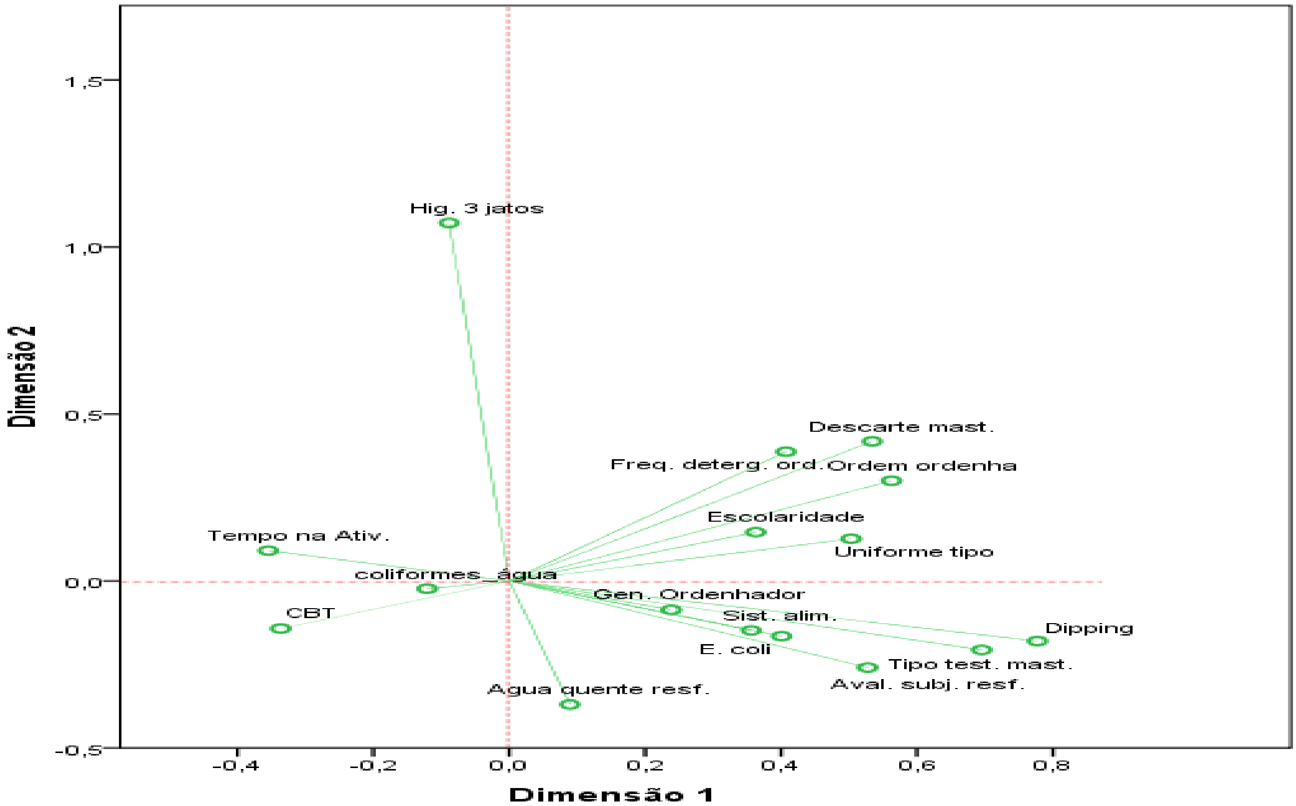

FIGURE 2- Representation of the PCA-2 factorial plan - Milking Technology.

Regarding the hygiene practices adopted for milking, Monteiro et al. (2007) observed that 65.9% of the farms studied used some hygiene practice during milking, the pre and post-dipping managements being the lesser used practices.

Other factors that were influenced by time in dairy activity were the feeding system employed, the milker gender and the presence of thermaltolerant coliforms in milk. The increasing in TBC through the feed system employed is related to the food supply to the animals during milking. Thus, the food supply to the animals during milking was verified in properties whose time in the activity was higher.

It was also observed the presence of thermotolerant coliforms in milk whose the time in the activity was longer. Thus, we can mention that the presence of this microorganism is related to the use of products for pre and post-dipping and also the tests for mastitis, inefficient in the properties with longer time in the dairy business. While total coliforms indicate contamination from the environment, the presence of Escherichia coli (thermaltolerant coliforms) indicates fecal contamination and the presence of pathogens (FRANCO; LANDGRAF, 2008). Finally, time in the activity was related to the producer's education, thus demonstrating that producers with shorter time in the dairy business have higher education level.

For the analysis of typology were formed five groups. The system 1 represented the first Group 1 being characterized by not performing the management of the withdrawal of the first three jets before milking, and this practice is directly related to avoid the increased TBC.

According to Silva et al. (2011), they found that the first three milk jets showed high counts for all microbial groups, being one important point to be considered for the milk contamination control. Matsubara et al. (2011) noted that with the elimination of the first three jets, it is considered 100% reduction of microorganisms at this point, once they simply cease to be incorporated in the milk in its entirety.

Group 2 was represented by 20 systems (2, 4, 6, 7, 8, 10, 11, 12, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 30, 31) and was characterized by the completion of the three first jets before milking and the completion of pre and post-dipping. The use of these practices is important tools to avoid increased TBC and thus maintain the milk quality.

Brito et al. (2000) proved the pre-dipping efficiency compared to use of tap water, using the bacterial count of the teats skin as parameter. Miguel et al. (2012) concluded that the pre-dipping was an important tool to reduce skin contamination by teats, demonstrating the obvious risk potential of milk contamination when not practiced.

Group 3 was composed of the systems 3 and 29 being typical by having semi-confined feed system, using hot water for sanitizing the storage tank, but by having the presence of thermltolerant coliforms in milk. The use of hot water for cleaning is a tool to increase the detergents efficiency in cleaning; however, the water to be used should be of good quality, because when contaminated with pathogenic microorganisms can result in milk contamination. Santana et al. (2001) found that the practice of using water heated to about 100 ºC for hygiene liners, resulted in lower initial counts of mesophilic and psychrotrophic.

Group 4 consisted of five systems (5, 13, 14, 25, 32) being characterized by carrying out tests for mastitis detection, use frequency of detergents in the cleaning of milking equipment and uniform use.

Thus, the use of these practices by producers can be considered a way to reduce or avoid high counts of TBC, but also the tests for mastitis detection a way to avoid milk contamination for mastitis and the drugs used, as to avoid high SCC values in the cooling tank. Matsubara et al. (2011) showed reductions in contaminations by 99.6% for TBC after liners being sanitized as recommended.

The systems 9, 15, 16 and 24 represented the Group 5 and were characterized by not performing the pre-dipping. This practice combined with the discard of the first three jets at the milking beginning is the major tool to avoid milk contamination and avoid high counts of CBT, as well as prevent the mastitis occurrence.

After dipping the teats in a 750ppm chlorine solution, Matsubara et al. (2011) observed that the mean count of microorganisms showed reductions of 91.3% for total coliforms and 87.3% for aerobic mesophilic (TBC).

The representation of Principal Components Analysis 3 (PCA-3), as its typology for the 32 SPL, is in Figure 3. The PCA-3 was characterized as "Production Scale", where the variables were related to milk production itself and the technification of the milking system.

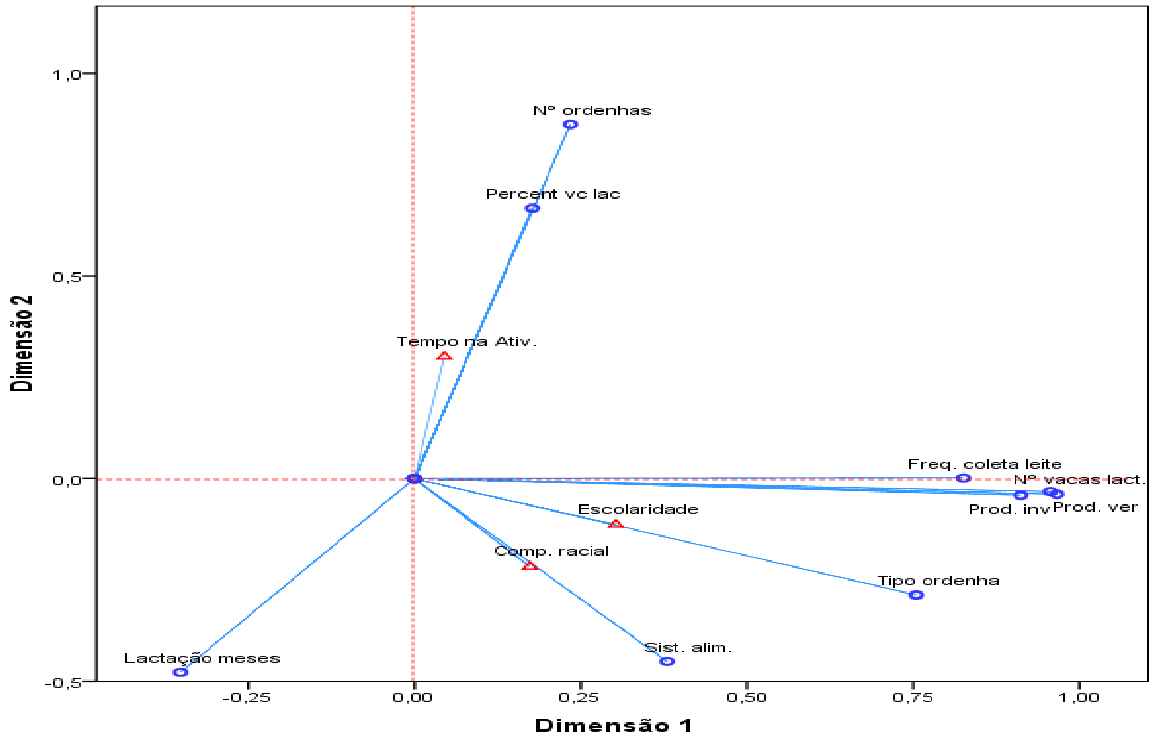

FIGURE 3 - Representation of the factorial plan of PCA-3 - Scale Production.

The contributions of the first two principal components of the factorial analysis of PCA-3 (production scale) determined that the first principal component (Dimension 1) explains 47.805% of the variance and the second (Dimension 2) explains 19.169%, totaling 66.974% for the first two components.

The principal component 1 was characterized by the milk production related to production variables in summer and winter seasons, the number of dairy cows, milk collection frequency and type of milking. The principal component 2 was characterized by the type of production, where the related variables were the number of milkings carried out on the day and percentage of lactating cows and, to a lesser extent by the time in the dairy business.

The yields in winter and summer were linked. The highest milk yields were related to the number of dairy cows and the milking type utilized, thus demonstrating that larger herds of animals favor an increased production, and consequently the use of improved technologies for milking. Thus also, the higher milk production influenced the higher frequency of milk collection by the dairy, or the daily milk collection.

The influence of producer's education on the milk production and the number of dairy cows was verified, i.e. the producer's education level had importance for the increasing production and the number of cows on the property. The confined feeding system, in which animals receive food completely in the trough, was more observed where there was higher daily milk production with highly technified milking system. Where the system was extensive, the use of bucket milking system was predominant.

In properties with lower number of lactating animals was observed that the lactation duration was greater compared to the others. However, this effect may result from lower intensification of production.

For the typology, the distribution of properties groups relating to the PCA-4 (Production Scale) can be observed in Figure 3. Group 1 consisted of 22 systems (1, 2, 3, 5, 7, 8, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 25, 27, 31 32) and characterized by performing two daily milkings and lactation longer than 9 months. The completion of two milkings per day in the properties is the most commonly used, as it requires less dairying intensification. The lactation duration longer than 9 months is a sign of persistent lactation animals, with potential for milk production.

Group 2 consisted of five systems (4, 9, 23, 24, 29) being characterized by the frequency of milk collection made daily by the industry and by having a percentage of lactating cows above 80%.

The frequency of milk collection was considered a factor to raise the CBT. Currently, the dairy industry has sought to make the collection every two days aiming at reducing costs. However, this cost savings may result in loss of milk quality, if the cooling system of the storage tank is not efficient, and thus the longest time between milk collections may influence the TBC increase. Fagundes et al. (2006), point out that although the milk cooling immediately after milking is a mandatory measure, this does not guarantee the product quality, strengthening that it is obtained under sanitary conditions suitable for reducing the possibility of initial contamination.

Group 3 was formed by systems 6, 28 and 30, being characterized by the percentage of lactating cows in the herd over 90%, performing three daily milkings and possessing highly technified milking system. The completion of 3 milkings is most viewed on properties with high milk production, and most often requires the use of hand labor contractor, and if so, hygiene practices are limited to this. Vallin et al. (2009) observed that the mean TBC found in properties with mechanical milking was around three times higher than the mean found in farms with manual milking before and after milking hygiene practices deployed, indicating that the technological level of milking does not necessarily result in better quality milk and depending on how it is used, it can be a source of bacterial contamination.

The system 13 represents Group 4 and was characterized by high milk production, above 1500 liters/day, and the number of lactating cows higher than 100 animals. In this case, the system displayed by this property was based on a free-stall installation and high technology milking system. Bramley and McKinnon (1990) reported that in the U.S., the counts performed on cleaned teats of grazing animals are lower than those of cattle kept in sand bed. Also, Miguel et al. (2012) observed increased bacterial count of teatcups surfaces, when increasing the number of milked animals.

The system 26 represents Group 5, characterized by extensive production, totally pasture. The use of an extensive production by this property was based on reduction in food production costs; however, they performed the milking hygiene practices. This study evaluated the use of products for pre-dipping was neglected, when in properties with high daily milk production. However, this can be an important factor to maintain the milk quality, since the handling of pre-dipping reduces the TBC.

By the principal component analysis, it was observed that the practices used in the milking management to maintain the milk quality exert influence on milk components, especially on the milk sanitary quality. However, the use of these practices is mainly related to the producer's characteristics influence their decisions. The typology enabled the formation of groups of dairy systems distinct from each other, regarding the implementation of these practices, but also the milk quality and intensification of the dairy system on the property.

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