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Socioeconomic and technical assistance factors related to total bacteria count and somatic cell count of milk from bulk tanks in southern Minas Gerais State, Brazil

Fatores socioeconômicos e de assistência técnica relacionados a contagem bacteriana total e células somáticas do leite de tanques no sul do estado de Minas Gerais, Brasil

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ABSTRACT

The purpose of this survey was to evaluate the socioeconomic and technical assistance profiles of dairy farmers from six districts in the south of Minas Gerais state, Brazil, and to identify the possible risk factors associated with total milk bacteria count (TBC) above 43,000 CFU mL^{-1} and bulk milk somatic cell count (BMSCC) above 595,000 cells mL^{-1}. Most of the producers were between 41 and 60 years of age (48.9%), 74.2% did not reach high school, and 72.3% of the respondents were satisfied with their profession, although 63% would not recommend dairy farming to their children. Only 34.7% used periodic technical assistance, but 59.1% consulted it in cases of doubt. The risk factors found in the final multivariable regression models were: TBC (Did not consult technical assistance in case of doubt, OR 3.97, P=0.030; Retirement, OR 9.32, P=0.041) and BMSCC (Producer does not reside on farm, OR 4.06, P=0.046; Presence of technical assistance OR 3.29, P=0.041). It can be concluded that the search for emergency technical assistance, as reported by farmers, was effective against the TBC problems; however, it was ineffective for controlling mastitis in the herd and reducing BMSCC levels. The 10 step mastitis control program from the National Mastitis Council needs to be included on the surveyed farms, especially the permanent advisory technical assistance from veterinarians, aiming towards the establishment of goals for udder health status, reviews and records.

Key words: *cultural level, livestock, risk factors, milk quality.*

RESUMO

O objetivo desta pesquisa foi avaliar o perfil socioeconômico e de assistência técnica de produtores de leite provenientes de seis cidades no sul do estado de Minas Gerais, Brasil, e identificar os possíveis fatores de risco associados com a contagem bacteriana total (CBT) do leite acima de 43.000 UFC mL^{-1} e contagem de células somáticas do leite do tanque (CCST) acima 595.000 células mL^{-1}. A maioria dos produtores possuía entre 41 e 60 anos de idade (48,9%), 74,2% não alcançaram o ensino médio e, 72,3% dos entrevistados estavam satisfeitos com a sua profissão, embora 63% não recomendaria a pecuária leiteira para os seus filhos. Apenas 34,7% utilizaram assistência técnica periodicamente, mas 59,1% a consultava em caso de dúvidas. Os fatores de risco encontrados nos modelos finais de regressão multivariada foram: CBT (Não consulta a assistência técnica em caso de dúvidas, OR 3,97 e P=0,030; Aposentadoria, OR 9,32 e P=0,041) e CCST (Produtor não reside na fazenda, OR 4,06 e P=0,046; Presença de assistência técnica OR 3,29 e P=0,041). Pode-se concluir que a busca por assistência técnica de forma emergencial, conforme relatado pelos agricultores, foi eficaz contra os problemas de CBT; no entanto, ineficaz para o controle de mastite no rebanho e na redução dos níveis de CCST. O programa de controle de mastite de 10 pontos do National Mastitis Council *precisa ser incluído nas fazendas pesquisadas, especialmente em relação à assessoria técnica permanente por veterinários, visando o estabelecimento de metas para o status de saúde do úbere, revisões e registros.*

Palavras-chave: *nível cultural, pecuária, fatores de risco, qualidade do leite.*

INTRODUCTION

The dairy activity is present all over Brazil, generating income, employment and taxes. The State of Minas Gerais deserves attention in milk production and in the third quarter of 2013, 1,553.256 billion liters of milk was obtained, representing 25.9% of the

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total in the country in this period, slightly increasing its share over the same 2012 period (IBGE, 2013). However, the last decades have witnessed profound social, economic and cultural factors, affecting production routines, social relations, commercial and labor relationships in Brazil. This current context produced new social inequalities that required public policy alternatives to improve the situation in general and milk quality in particular.

In the mid-1990s, the dairy industry began implementing programs to pay for milk quality improvement efforts in Brazil as a tool to encourage producers to seek improvement of their product and, indirectly, to obtain better industrial performance and to become established in the international market. A systematic approach to production process problems is one of the most important aspects of quality programs. The tools for a systematic approach consist of explanatory, observational and epidemiological studies, which identify and quantify factors that determine the occurrence of a problematic sector (SOUZA et al., 2005).

Several studies have emphasized the importance of management practices and monitoring the behavior of milkers to maximize production, animal welfare and hygienic-sanitary quality of the milk produced (SOUZA et al., 2005; PANTOJA et al., 2009; ELMOSLEMANY et al., 2009; BARLOW, 2011; BARKEMA et al., 2013). The risk factors affecting milk hygienic-sanitary quality and the socioeconomic profiles and technical assistance information available to farmers in emerging countries, specifically in Brazil, have not yet been reported.

Given the importance that milk quality has to the entire milk production chain, this study aimed to identify the socioeconomic profiles and the use of technical assistance of 96 dairy farmers from six cities in southern Minas Gerais State, located in southeast Brazil, and to determine if these factors were associated with levels of bulk milk total bacterial count (TBC) and bulk milk somatic cell count (BMSCC).

MATERIALS AND METHODS

A questionnaire, with three general questions (production system, breed of the animals and milking type) and 15 specific questions (related to hypothetical socioeconomic characteristics and the necessity for technical assistance in practices that could influence the incidence of low TBC and high BMSCC) was developed using the structured process method (SCHOLL et al., 1992). Some specific questions were based on the surveys of KUIPER et al. (2005) and JANSEN et al. (2010). Others questions were developed because literature regarding this topic is still scarce. The interviewers were trained to use the questionnaire, and it was validated in a group composed of 12 farmers. Efforts were made to identify the possible confounders and effect-modifiers, according to the method of DUFOUR et al. (2010). The questionnaire was used during December of 2011 with 96 dairy farmers (randomly selected using random numbers from a sampling frame that included all dairy farmers, n=149) located in six towns (Bom Sucesso, Ibituruna, Ijaci, Itumirim, Lavras and Ribeirão Vermelho) in southeast Minas Gerais state, Brazil, who commercially sell milk to a dairy plants in the Lavras region. For the initial presentation of the data, the producers were classified according to age group, and a frequency table was formulated.

For the daily milk production and analyses of TBC and BMSCC values, data from a range of 12 months were utilized, six months before and after the end of the questionnaire, to promote a greater reliability of the data. Of the 96 dairy farmers who participated in the study, 11 did not want to identify themselves on the questionnaire, so they were excluded from the analyses of TBC and BMSCC. At least once a month, milk samples from bulk tanks were collected aseptically in sterile plastic vials, immediately cooled, packaged and sent to the Milk Clinic at the University of São Paulo (USP/ESALQ). BMSCC analyses were performed using Bentley Combi System 2300® electronic equipment (Bentley Instruments Inc., Chaska, USA), and the TBC evaluation was performed using BactoCount IBC® electronic equipment (Bentley Instruments Inc., Chaska, USA).

A logarithmic transformation of the means for TBC and BMSCC was performed to obtain a normal distribution of the data. Then, analysis of variance was performed using the software SISVAR® 5.3 (FERREIRA, 2011), and means were compared with the Scott-Knott test ($P \leq 0.05$). Chi-square tests and logistic regression (PAGANO & GAUVREAU, 2000) were used to assess the associations between TBC, BMSCC, socioeconomic characteristics and the use of technical assistance. Bivariate and multivariate regression analyses were performed using SPSS® 17.0 (STATISTICAL.., CHICAGO, UNITED STATES, 2008).

For the chi-square tests, bivariate analysis and the construction of the final regression model (multivariate), the responses from the questionnaire

(regardless of the age of the producers) and the means for TBC and BMSCC were categorized. The TBC and BMSCC means were categorized as below or above the levels of 43,000 CFU mL^{-1} and 595,000 cells mL^{-1}, respectively. The current standard value of milk quality in Brazil for TBC (600,000 CFU mL^{-1}) (BRAZIL, 2011) was not used because the majority of farmers (85.8%) had a mean below that standard. This would have reduced the effectiveness of the test because a maximum of 70% and a minimum of 30% of responses between the classes are recommended.

Independent variables (IV) (questions about socioeconomic characteristics and the necessity for technical assistance of producers) were selected and obeyed the distribution frequency of the classes (at least 30%), and then bivariate regression analyses were conducted with the dependent variables (DV) (TBC and BMSCC classes) to identify the explanatory variables and interaction terms ($P \leq 0.20$). A logistic regression series (multivariate) for each DV and IV was performed using forward and backward variable selection procedures and the significance of variables (PANTOJA et al., 2009) to find the best values for the "Hosmer-Lemeshow goodness of fit test" and the "P value" for the final regression model. The level of statistical significance was set at 0.05 for all analyses.

RESULTS AND DISCUSSION

The investigated production systems were semi-confined (45.2%, n=45), grazing (42.2%, n=44), and total confinement (4.8%, n=5). In 1.92% of the cases (n=2), the data were omitted. Regarding the milk analysis, 85.9% (n=73) and 57.6% (n=49) were below the value limits set by the current legislation in Brazil (600,000 CFU mL^{-1} and 600,000 cells mL^{-1}) for TBC and BMSCC, respectively (BRAZIL, 2011). The means and standard deviations for TBC (Log_{10} CFU mL^{-1}) were 4.99±0.604 and 5.65±0.232 for BMSCC (Log_{10} cells mL^{-1}). The means for TBC (Log_{10} CFU mL^{-1}) and BMSCC (Log_{10} cells mL^{-1}) by producer age group were up to 40 years [4.95 (±0.672); 5.63 (±0.243)]; 41 to 60 years [4.92 (±0.605); 5.67 (±0.226)]; and more than 60 years [5.13 (±0.552); 5.60 (±0.239)], with no significant differences between the age groups using the Scott-Knott test ($P \leq 0.05$).

The socioeconomic profiles and information regarding technical assistance from the 96 farmers interviewed, classified according to age for the year 2011 are presented in table 1. Most of the producers reported that they completed their studies between the 1st and 4th grades; however, the largest share of producers under 40 years old had completed high school. This revealed that producers in the lower age groups had a higher education level. Of the respondents, the vast majority live on their dairy farms and have children (maximum of three), and most of them attend or have attended school (Table 1). Approximately 60% (n=13) of the farmers interviewed over 60 years old reported that they have no retirement benefits (Table 1).

Approximately one-third of respondents reported that they had another source of income in addition to their farming activities, and this percentage decreased as age increased. This revealed that younger dairy farmers are concerned about having a source of extra income. Approximately one-third of the producers reported that they would change professions, and most would not recommend dairy farming to their children, especially producers between 41 and 60 years old (Table 1). BRAGG & DALTON (2004) reported that producers who had extra incomes arising from non-agricultural activities were more likely to abandon farming activities.

Most producers received no technical assistance, especially the farmers over 60 years of age; however, they considered it important. This awareness was higher for lower ages. Most producers reported that it was not fair to have to pay for technical assistance services, with the exception of producers in the lower age groups. Similar results were found by IBGE (2006), where only 22% of farms investigated received technical guidance.

Most producers (64.1%, n=59) responded that they would like to change their way of working. According to BARKEMA et al. (2013), problems on the farm, such as high BMSCC, can be solved if farmers are sufficiently motivated, if farm advisors are sufficiently knowledgeable, and if farmers and advisors work together to execute a jointly determined plan. Furthermore, to improve the efficiency of the mastitis control program and, consequently, effective BMSCC control, the NMC (National Mastitis Council) has developed a list of 10 steps to follow in a mastitis control program (NMC, 2004). This list includes the establishment of goals for udder health status and, if necessary, a review of the goals on a timely basis, giving priority to the management changes necessary to achieve it. It also includes the periodic monitoring of udder health status and review of the mastitis control program with input from the herd udder health advisory team (veterinarian, producer, herd manager, milkers and advisors), thus, motivating the producers and helping then to achieve their goals.

Table 1 - Socioeconomic profiles and information regarding technical assistance from the 96 interviewed farmers located in six counties in the south region of Minas Gerais state, southeast Brazil, classified according to age, in the year 2011.

Question	Inquiry	All ages(n=96)		Up to 40 years (n=15)		41 to 60 years (n=47)		Above 60 years (n=22)	
		n	%	n	%	n	%	n	%
Level of education	Can only write their name	4	4.3	0	0.0	3	6.4	1	4.5
	Read and write	4	4.3	0	0.0	1	2.1	3	13.6
	1st to 4th grade	41	44.1	4	26.7	22	46.8	12	54.5
	5th to 8th grade	20	21.5	4	26.7	10	21.3	1	4.5
	High school	19	20.4	6	40.0	10	21.3	3	13.6
	Higher education	5	5.4	1	6.7	1	2.1	2	9.1
Live on the milk farm?	Yes	73	78.5	12	80.0	33	71.7	19	86.4
	No	20	21.5	3	20.0	13	28.3	3	13.6
Number of children?	None	9	10.2	3	20.0	3	6.9	1	4.5
	Less than 3	66	75.0	12	80.0	35	79.5	14	63.6
	3 or more	13	14.7	0	0.0	6	13.6	7	31.8
Children attend (or attended) school?	Yes	64	78.0	10	83.3	38	88.4	11	57.9
	No	18	22.0	2	16.7	5	11.6	8	42.1
Own retirement?	Yes	23	24.7	0	0.0	3	6.5	9	40.9
	No	70	75.3	15	100.0	43	93.5	13	59.1
Have another source of income?	Yes	29	31.5	5	33.3	12	26.7	3	14.3
	No	63	68.5	10	66.7	33	73.3	18	85.7
Would like to change job?	Yes	26	27.7	4	26.7	17	36.2	3	14.3
	No	68	72.3	11	73.3	30	63.8	18	85.7
Recommend dairy farming as a source of income for the children?	Yes	34	37.0	7	46.7	10	21.7	10	45.5
	No	58	63.0	8	53.3	36	78.3	12	54.5
Has periodic technical assistance?	Yes	33	34.7	6	40.0	16	34	5	22.7
	No	62	65.3	9	60.0	31	66	17	77.3
Consider technical assistance necessary?	Yes	61	66.3	11	73.3	32	69.6	12	54.5
	No	31	33.7	4	26.7	14	30.4	10	45.5
Think it fair to pay for technical assistance?	Yes	24	34.3	6	54.5	9	25	6	35.3
	No	46	65.7	5	45.5	27	75	11	64.7
In case of doubt, what is the procedure?	Seek assistance	55	59.1	11	73.3	25	53.2	14	66.7
	Resolve alone	25	26.9	3	20.0	14	29.8	6	28.6
	Consult a neighbor	13	14.0	1	6.7	8	17	1	4.8
Would change your way of working?	Yes	59	64.1	10	71.4	31	66.0	12	54.5
	No	33	35.9	4	28.6	16	34.0	10	45.5

In cases where frequencies differed from the total cases, data were omitted. (%): the number of cases examined, not total cases. Twelve producers did not respond to the age question.

The final regression models (multivariable) for the socioeconomic characteristics, the need for technical assistance and the risks associated with TBC and BMSCC are presented in table 2. The TBC model identified that producers who consulted neighbors or solved their problems alone were 3.97 times more likely (P=0.03) to have a mean TBC above 43,000 CFU mL^{-1}, compared with those who sought technical assistance. According to GREEN et al. (2012), milk being hygienically obtained from healthy cows, followed by immediate cooling to 4ºC are the primary and fundamental measures to ensure microbiological quality; however, if these basic skills are not passed on to producers clearly and objectively, the targets will not be met. This survey revealed that receiving technical assistance was effective for controlling TBC because, in general, the measures to be adopted are relatively simple and the results are seen immediately after the application of good agricultural practices for milk quality.

The retirement of the producers was another identified risk associated with TBC, and this class of producers was 9.32 times more likely to have TBC values above 43,000 CFU mL^{-1} (P=0.041), compared to producers who did not have retirement benefits (Table 2). SILVA (2001) reports that rural Brazilian families are becoming increasingly non-agricultural, relying on social transfers (pensions) and non-agricultural occupations. This survey revealed that retired producers were less concerned with the quality of the milk because the milk activity was less represented in their monthly income. However, the age of these retired producers must be considered as a limitation, and from the 21 total producers that have such benefit, 76.19% (n=16) are at least 65 years old. According to PALLONI & PELÁEZ (2003) the aging process, which occurs gradually in developed countries, accompanied by improvements in the coverage of the health system, housing conditions, sanitation, work conditions and nutrition, occurs rapidly in Brazil and in a context of social inequality, fragile economy, increasing levels of poverty, with poor access to health services and limited financial resources, without the structural changes that respond to the demands of the new emerging age group.

The final regression model for BMSCC showed that the producer's place of residence was a factor associated with lower levels of BMSCC. Producers who did not live on their dairy farms were 4.06 times more likely (P=0.046) to have a BMSCC level above 595,000 cells mL^{-1} (Table 2). This suggests that producers who reside on their farming properties paid greater attention to the control of mastitis in the herd and routinely checked the workers.

This survey revealed that the producers who received periodic assistance from a veterinarian

Table 2 - Final regression models (multivariable) for the socioeconomic characteristics, need for technical assistance and the risks associated with total bulk milk bacterial counts (TBC) and bulk milk somatic cell count (BMSCC) from 85 producers located in six counties in the southern region of Minas Gerais state, southeast Brazil, in the year 2011.

Independent Variable	Coefficient	SE	P	OR (β)	CI 95%	
					ICI	SCI
Final logistic regression model for the TBC (above 43,000 UFC mL^{-1}) (P model=0.008; Hosmer and Lemeshow test=0.91)						
*In case of doubt, what procedure is taken (Talk to the neighbor or solve alone *vs.* Seek assistance)	1.38	0.64	0.030	3.97	1.1	13.8
*Own retirement (Yes *vs.* No)	2.23	1.09	0.041	9.32	1.0	79.0
Level of education (Up to the 8th year *vs.* Higher than 8th year)	0.29	0.63	0.650	1.03	0.3	4.6
Production system (Semi-confined or fully confined *vs.* Grazing)	-0.51	0.60	0.397	0.60	0.1	1.9
Final logistic regression model for the BMSCC (above 595,000 cells mL^{-1}) (P model=0.005; Hosmer and Lemeshow Test=0.72)						
*Live on the property (No *vs.* Yes)	1.40	0.70	0.046	4.06	1.0	16.0
Would like to change job (No *vs.* Yes)	-0.51	0.69	0.459	0.60	0.1	2.3
*Count on technical assistance (Yes *vs.* No)	1.19	0.58	0.041	3.29	1.0	10.3
Would like to change the way of working (No *vs.* Yes)	0.95	0.58	0.098	2.60	0.8	8.0

*Significant (P<0.05); SE=Standard error of the estimate; P=Probability; OR (β) =Odds ratio; IC=Confidence interval; ICI=Inferior confidence interval; SCI=Superior confidence interval.

(at least once and a maximum of two visits per month) were 3.29 times more likely (P=0.041) to present BMSCC above 595,000 cells/mL compared with producers who did not receive such assistance (Table 2). Such a result is somewhat expected because more frequent efforts are made by the professional dairy milk teams on these properties to meet legislated BMSCC standards to increase industrial yield. However, producers seek technical support only when the BMSCC levels are critical. According to KUIPER et al. (2005), many farmers believe that their knowledge of mastitis control practices on the farm is sufficient, seeking assistance only in extreme cases. This fact suggests that producers which do not count on periodic veterinarian assistance, until now, have no problems with BMSCC. Moreover, according to LANGONI (2013), the multiple etiology of mastitis pathogens demands a rigorous milk quality control and monitoring program, including diagnostic actions and epidemiological vigilance, especially the indirect parameters associated, such as California Mastitis Test (CMT) and Somatic Cell Count (SCC) of individual cows and bulk tanks, which also allows for the total bacteria count, usually related to the mastitis incidence, especially in subclinical cases.

Unlike milk TBC control programs, which are easier to apply, BMSCC control programs require producers to spend time and make decisions regarding the adoption of hygiene-health management practices and antibiotic therapies (BARLOW, 2011); the implementation of proper milking and maintenance procedures and the correct use of milking equipment and regular monitoring of udder health status (NMC, 2004); the culling of chronically infected cows, identification of clinical and subclinical cases and, in some cases, vaccination of the herd (GREEN et al., 2012); the monitoring of cows with high parity order and a history of clinical mastitis during previous lactations and effectiveness of the dry cow treatment (PANTOJA et al., 2009); and the definition of short- and long-term goals, including the formulation and implementation of a herd management plan and evaluation of the results (BARKEMA et al., 2013) according to the NMC 10 steps mastitis control program. All those procedures must be considered to a proper BMSCC control program, including a permanent veterinary advisory, preventing the raise of this parameter to critical levels.

Another factor that could increase the prevalence of mastitis in the herd is high milk production by the cows, which causes higher metabolic activity in the tissues, free radical production and oxidative stress, increased antioxidant defense by the cows, and an increase in health disorders (SORDILLO & AITKEN, 2009). In this survey, the majority (94.8%, n=91) of the herds were crossbreeds (Holstein or Jersey x Bos taurus indicus), while only 5.2% (n=5) of herds were exclusively Holstein cows, with a daily mean milk production of 8.9±4.55 (Liters day $^{-1}$) and a low number of lactating cows (27.33±22.74), which reduces the risk factor described above.

However, other factors may be considered, such as daily milk production and milking type of the farms. BORGES et al. (2013) analyzing the milk quality in different milk production ranges in regions of Brazil, found that the BMSCC complied with the legal requirements of 600,000 cells mL^{-1}, except for the range with a daily production above 1,000 liters and the total bacterial count was the most critical quality factor, with the highest values found in breeds with milk production above 500 liters per day. In our survey, the means for TBC (Log_{10} CFU mL^{-1}) and BMSCC (Log_{10} cells mL^{-1}) for daily milk production ranges were up to 150 liters day^{-1} (n=48) [5.28 (±0.54); 5.66 (±0.24)]; from 151 to 500 liters day^{-1} (n=23) [4.74 (±0.46); 5.64 (±0.23)]; and more than 501 liters day^{-1} (n=12) [4.37 (±0.28); 5.65 (±0.14)] with significant differences between the daily milk production groups for TBC, using the Scott-Knott test (P≤0.05), showing a lesser adoption of hygiene practices during the milking of the herds and/or milk refrigeration problems in the lowest production ranges, in disagreement with the survey of Borges et al. (2013). On 13 farms, the daily milk production data was omitted.

Regarding the milking type of the farms, 40.6% (n=39) were manual (M), and 59.4% (n=57) were mechanical systems (MS). GREEN et al. (2012) reported that some milking machine malfunctions may impact mammary health, increasing the predisposition for mastitis. However, in our survey, the milking type classes did not differ in mean BMSCC (Log_{10} cells mL^{-1}) [M - 5.62 (±0.242); MS - 5.64 (±0.200)]. In contrast, significant differences for these classes were found using the Scott-Knott test (P≤0.05) for TBC means (Log_{10} CFU mL^{-1}) [M - 5.29 (±0.530); MS - 4.78 (±0.555)], and this was most likely due to lack of adoption of hygiene-health management practices (BARLOW, 2011), improper milking procedures (NMC, 2004) or inefficiency of the cooling system (GREEN et al., 2012) in manual systems.

However, these variables (milk production range and milking type) were not used in either final regression model due to a confounding

effect that these provoked in the other variables and to the low effectivity of the models.

CONCLUSION

In conclusion, some socioeconomic and technical assistance factors were significantly associated with some aspects of the quality of bulk tank milk. Greater efforts from professional rural extension teams were made for herds with higher BMSCC levels, targeting the compliance of these producers with current Brazilian legislation. As reported by farmers, the search for emergency technical assistance was effective against TBC problems but ineffective for controlling mastitis in the herd and reducing BMSCC levels (which require more attention from farmers and dairy milk extension teams). The 10 step mastitis control program from the National Mastitis Council needs to be included on the surveyed farms, especially the permanent advisory technical assistance from veterinarians, aiming towards the establishment of goals for udder health status, reviews and records.

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RESEARCH ETHICS COMMITTEES

This survey was approved by the bioethics committee, protocol number 132.569 recorded in Brazil Platform.

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