Milk quality from Western Santa Catarina in the period of 2009 - 2010

Qualidade do leite do Oeste de Santa Catarina no período de 2009 - 2010

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Abstract

The objective of the present study was to evaluate the quality of refrigerated raw milk produced by 912 farmers in the Western part of Santa Catarina State, Brazil. The parameters analyzed were fat, protein, lactose, solids nonfat (SNF) content, standard plate count (SPC) and somatic cell count (SCC). A comparative analysis study with data from 2009 and 2010 was also conducted, which has shown that SCC influenced on the physico-chemical results. It was also observed that in 2010 the values for SCC were higher than in 2009, out of the limits recommended by the legislation until 2011. The SPC values were well above the maximum level accepted, indicating high contamination of milk with aerobic mesophilic microorganisms. The data collected indicated that only 4.9% of the producers sampled in 2009 and 8.1% in 2010 were in compliance with the standards enforced by a new legislation of January 2012. There was also increase on the milk fat content as SCC increased, which was not observed with other milk components. Lactose had a gradual reduction as SCC increased. On the other hand, SNF content did not correlate with SCC variance. These results demonstrate the urgent need of improvement in milk production and better technical orientation of milk producing properties to reach higher quality standards in Santa Catarina.

Keywords*: Somatic cell count. Milk. Western of Santa Catarina State.*

Resumo

O objetivo deste trabalho foi avaliar a qualidade do leite cru refrigerado produzido por 912 produtores rurais do oeste catarinense, considerando a gordura, proteína, lactose, extrato seco desengordurado (ESD), contagem padrão em placa (CPP) e da contagem de células somáticas (CCS). Efetuou-se ainda análise comparativa entre os anos de 2009 e 2010, e verificou-se a influência da CCS nos resultados físico-químicos obtidos. Observou-se que em 2010 os valores para CCS foram maiores do que em 2009, fora do padrão exigido pela legislação vigente até 2011. A CPP apresentou-se muito acima dos níveis desejados, indicando elevada contaminação do leite por

microrganismos mesófilos aeróbios. Os dados indicam que dos produtores amostrados, apenas 4,9% em 2009 e 8,1% em 2010 estão dentro dos padrões exigidos pela legislação, quando considerado as contagens de CCS e CPP combinadas e a legislação vigente a partir de janeiro de 2012. Houve ainda um aumento no percentual de gordura do leite proporcional ao aumento da CCS, fato não observado nos outros parâmetros avaliados. A lactose teve uma diminuição gradual conforme os aumentos na CCS, já o ESD não obteve correlação com CCS. Esses resultados demonstram a necessidade urgente de um maior acompanhamento da produção leiteira e melhorias na orientação técnica nas propriedades para que ocorra a adequação aos padrões de qualidade exigidos.

***Palavras-chave**: Contagem de células somáticas. Leite. Oeste Catarinense*

Introduction

Brazil is a large milk producer (FAO, 2012), however struggles to meet the quality standards required internationally, and therefore is restricted to export dairy products. The Ministry of Agriculture, Livestock and Supply (MAPA) stipulated more strict standards for physico-chemical and microbiological standards, with deadline for compliance initially until January 2012 (MAPA, 2002). It was subsequently amended by Normative Instruction n. 62 with deadline of July 2016. The intention is to improve Brazilian milk quality to international levels. The private sector, in order to achieve this goal, has established programs to pay for quality (GREEN et al., 2006; ROMA JÚNIOR et al., 2009; TSENKOVA et al., 2001), linking remuneration to the composition of milk to encourage producer to seek improvements during milk production. In addition, higher solid contents lead to better industrial performance which generates bonus for milk of high quality or penalties for milk of low quality (ROMA JÚNIOR. et al., 2009; STUBBS et al., 2009).

The western region of Santa Catarina State (Brazil) is well known for poultry and swine production, but milk production is also gaining merit. Dairy industries established in the region are following programs to verify milk quality. In this context, the somatic cell count (SCC) and standard plate count (SPC) can be used as indicators of milk quality (PANTOJA; HULLAND; RUEGG, 2009; LEITNER et al., 2006; LINDMARK-MANSSON et al., 2006; VANGROENWEGHE; DOSOGNE; BURVENICH, 2002). The SCC is used as an indicator of subclinical mastitis (LAKIC et al., 2011; LEITNER et al., 2006), which can cause economic losses to the dairy industry due to treatment costs, and reduction of production (VANGROENWEGHE; DOSOGNE; BURVENICH, 2002), also impairing the production of dairy products such as cheese (LEITNER et al., 2006). SPC is one parameter used to evaluate milk quality from the cooling tank, since it quantifies the total bacterial load, in order to verify if milking procedures or temperature during milking increased this count (VAN SCHAIK et al., 2005; MAPA, 2002).

The milk survey data from 2009 and 2010 on a dairy industry located in the Western of Santa Catarina State, Brazil, was conducted to evaluate milk nutritional composition and its level of SCC and microbiological contamination by aerobic mesophilic bacteria, based on the limits set by Instruction n. 62 (MAPA, 2011).

Material and methods

The study was performed with bovine raw milk supplied to a dairy industry located in the Western Region of Santa Catarina (-27°03'12''S and -52°04'00''W), from January 2009 to December 2010, representing a total of over 10,000 samples. Milk from 912 farms of five towns was studied (Ipumirim, Irani, Lindóia do Sul, Arabutã, and Concórdia). The milk samples from each farm was collected in sterile flasks before placing in the truck and sent to the laboratory under refrigeration (State Center of Research and Diagnostics in food – Unc, Cidasc), Concórdia (SC), accredited by MAPA. The physico-chemical and microbiological analyses, and somatic cell count were performed. All results were compared with the levels allowed by Brazilian legislation for raw milk (MAPA, 2011). Fat, protein and lactose were analyzed using

mid-infrared equipment (MIR Model 2000, Bentley Instruments, Chaska, USA) (IDF, 2000). The moisture content in milk was determined by an oven with forced air circulation, by drying it at 100 °C for 24h (AOAC, 2000). The total solids were calculated using the Fleischmann formula (MAPA, 2006). SPC and SCC were performed through flow cytometry (Model IBC, Bentley Instruments, Chaska, USA) (IDF, 2006). Data were evaluated by analysis of variance, complemented with the multiple comparison Student-Newman-Keuls test f. Differences were considered statistically significant at $p < 0.05$.

Results

Table 1 presents the average values for SCC and SPC observed in refrigerated raw milk for each year sampled. These values were evaluated based on the limits set by law up to December 2011 (MAPA, 2002) and since January 2012 (MAPA, 2011). Results were expressed as percentage of samples taken in accordance with considered limits.

Table 2 lists the ranges for SCC with all parameters measured in raw milk. The intervals followed the evolution of IN 51 and subsequently IN 62, published respectively in 2002 and 2011, seeking to become gradually stricter for different geographical regions. The results show the average annual levels for fat, protein, lactose, nonfat dry (ESD) and SPC within the ranges defined for SCC.

Discussion

The Brazilian government has implemented a schedule of adequacy for SCC and SPC in different regions of the country. In the case of the South, the limits for SCC and SPC became stricter from January 2012, progressively until 2016 (MAPA, 2011; MAPA, 2002). When evaluating the data presented in Table 1, it can be seen that the average value of SCC in 2009 does not exceed the current standard until late 2011. This was not observed for average values of SCC 2010, which exceeds the maximum allowed by Brazilian law. By using the standard in place since 2012, with a maximum for SCC of 6.0×10^5 cells/mL, both years studied were above this average value. Considering the average scores obtained in 2009 and 2010 for SPC values already exceed the standard maximum stipulated by legislation by the end of 2011 of 7.5×10^5 CFU/mL.

Table 1 – Averages of somatic cell count (SCC) and standard plate count (SPC) of refrigerated raw milk from 912 farms produced in the Western Santa Catarina State, Brazil, in the period 2009-2010

	SCC (cells/mL)	SPC (CFU/mL)
Standard	**Maximum $7.5 \times 10^{5*}$** **Maximum $6.0 \times 10^{5**}$**	**Maximum $7.5 \times 10^{5*}$** **Maximum $6.0 \times 10^{5**}$**
Year 2009 (n = 5393)		
Average values	$7.1 \times 10^5 \pm 9.1 \times 10^{3a}$	$4.9 \times 10^6 \pm 6.1 \times 10^{4a}$
Samples according to standard* (%)	68.0	10.4
Samples according to standard* for SCC and SPC (%)	7.4	
Samples according to standard** (%)	55.1	8.0
Samples according to standard** for SCC and SPC (%)	4.9	
Year 2010 (n = 4875)		
Average values	$8.5 \times 10^5 \pm 1.1 \times 10^{4b}$	$4.6 \times 10^6 \pm 7.5 \times 10^{4b}$
Samples according to standard* (%)	57.0	17.6
Samples according to standard* for SCC and SPC (%)	11.4	
Samples according to standard** (%)	45.6	14.3
Samples according to standard** for SCC and SPC (%)	8.1	

Note: Values shown as mean ± standard deviation. Different letters in the same column indicate statistically significant differences ($P < 0.05$).
Source: Limits set by Brazilian legislation until 01/01/2012 * (BRASIL, 2002) and from 01/01/2012 ** (BRASIL, 2011).

Table 2 - Changes in the levels of fat, protein, lactose, solids nonfat (SNF) and standart plate count (SPC) in refrigerated raw milk from 912 farms located in the Western Santa Catarina State, Brazil, in the period 2009-2010, according to the ranges of somatic cell count (SCC)

	SCC intervals (cells/mL)							
	Up to 6.0 x 10^5		6.0 x 10^5 to 7.5 x 10^5		7.5 x 10^5 to 1.0 x 10^6		Higher than 1.0 x 10^6	
Period	**2009 (a)**	**2010 (b)**	**2009 (c)**	**2010 (d)**	**2009 (e)**	**2010 (f)**	**2009 (g)**	**2010 (h)**
Attributes								
Fat (g/100g)	3.93 ± 0,59	3.94 ± 0,60	3.94 ± 0,51	4.01 ± 0,61	4.01 ± 0,53	3.98 ± 0.64	$4.14 \pm 0.65^{a,b,c,d,e,f}$	4.00 ± 0.67^{g}
Protein (g/100g)	3.23 ± 0,25	3.29 ± 0.28^{a}	3.23 ± 0.26^{b}	$3.32 \pm 0.24^{a,c}$	$3.24 \pm 0.23^{b,d}$	$3.29 \pm 0.25^{a,c,e}$	$3.25 \pm 0.36^{b,d,f}$	$3.27 \pm 0.27^{a,c,d,e}$
Lactose (g/100g)	4.32 ± 0.25	4.38 ± 0.20^{a}	$4.24 \pm 0.25^{a,b}$	$4.30 \pm 0.20^{b,c}$	$4.23 \pm 0.20^{a,b,d}$	$4.28 \pm 0.20^{a,b,c,e}$	$4.16 \pm 0.27^{a,b,c,d,e,f}$	$4.22 \pm 0.24^{a,b,d,f,g}$
SNF (g/100g)	8.51 ± 0.45	8.70 ± 0.44^{a}	$8.42 \pm 0.48^{a,b}$	$8.68 \pm 0.41^{a,c}$	$8.42 \pm 0.37^{a,b,d}$	$8.67 \pm 0.40^{a,c,e}$	$8.37 \pm 0.53^{a,b,d,f}$	$8.66 \pm 0.50^{a,b,c,e,g}$
SPC* (UFC /mL)	4.8 x 10^6 ± 8.2 x 10^4	5.0 x 10^6 ± 1.3 x 10^5	5.2 x 10^6 ± 1.7 x 10^5	4.6 x 10^6 ± 2.2 x 10^5	4.8 x 10^6 ± 1.8 x 10^5	4.0 x 10^6 ± 1.5 x 10^5	5.0 x 10^6 ± 1.6 x 10^5	4.4 x 10^6 ± 1.2 x 10^5
n (%)**	55.16	45.60	12.93	11.41	13.31	14.54	18.60	28.45

Note: Values shown as mean standard deviation or as *mean ± standard error of the mean; ** Number of samples in relation to the total percentage of samples of the years 2009 (5393) or 2010 (4875). The superscript letters within the same line indicate that the result shows a statistically significant difference ($P < 0.05$) in the interval and year, as shown in parentheses in the coding line period.

Source: Research data.

By taking into account the most restrictive standard for SCC of 2012, with a limit of 6.0 x 10^5 cells/mL, only 55.2% of the samples of 2009 and 45.6% of 2010 would be within this standard. For SPC, considering a maximum limit of 6.0 x 10^5 CFU/mL in effect in 2012, they would fall to 8.0% in 2009 and 14.3% in 2010. Comparing both counts, considering the standard from 2012, the total values of the samples approved in 2009 would be 4.9% and 8.1% in 2010. The IN 51 provided limits of 4.0 x 10^5 cells/mL for SCC and 1.0 x 10^5 CFU/mL for SPC since July, 2011 (MAPA, 2002), adjusted afterwards by IN 62 (MAPA, 2011). If the data were evaluated based on these limits, the percentage of approval of the samples would be even smaller with values of 0.24% in 2009 and 0.94% in 2010.

The results presented in Table 1 show that the average values for SCC are above the recommended, and the percentage of samples that met the legislation limits decreased from 2009 to 2010. This indicates that in both years there were problems in controlling the herd to prevent mastitis and that a gradual improvement expected was not observed. High values of SCC in milk were also observed in studies conducted in other countries such as Tunisia (GARGOURI; HAMED; ELFEKI, 2008; HAMED; ELFEKI; GARGOURI, 2008) and China (GUO et al., 2010), and the United States were noted below (PANTOJA; HULLAND; RUEGG, 2009).

In studies conducted with raw milk from different regions of Brazil, SCC values observed were around 2.0 x 10^5 cells/mL (PAIVA et al., 2012); 1.8 x 10^6 cells/mL (LANGONI et al., 2011) and 4.4x10^5 cells/mL in the Southeast (REIS et al., 2006); 6.0 x 10^5 cells/mL in the Southern (BORGES et al., 2009); and 2.6 x 10^6 cells/mL in the Northeast (LACERDA; MOTA; SENA, 2010). Another study also evaluating milk quality from Pantanal region, Central West of Brazil, observed counts of 1.35 x 10^5 cells/mL in raw milk produced in accordance with government regulations, and 8.43 x 10^5 cells/mL in milk commercialized without supervision and sold to consumers without pasteurization (LUZ et al., 2011).

There is no consensus among authors on the appropriate values for SCC. Some consider that milk

from healthy cows presents SCC values lower than 2.0 x 10^5 cells/mL (BREEN; BRADLEY; GREEN, 2009; GUO et al., 2010; PANTOJA; HULLAND; RUEGG, 2009) and animals with subclinical mastitis, usually show counts between 2.0 x 10^5 and 5.0 x 10^5 cells/mL, reaching values on the order of millions of cells per milliliter (GUO et al., 2010). Some authors consider that only values greater than 4.0 x 10^5 cells/mL indicate that the animal has subclinical mastitis (GARGOURI; HAMED; ELFEKI, 2008; HAMED; ELFEKI; GARGOURI, 2008). In the United States, the maximum allowed is 7.5 x 10^5 cells/mL for raw milk (FDA, 2009; NMC, 2013), but there is proposal to decrease it to 4.0 x 10^5 cells/mL after January, 2014 (NMC, 2013). The main measures used in countries like the United States to obtain milk with lower SCC, as well as pathogens and contaminants in general, includes control of herd health, detailed description of facilities, milking procedures, cleaning and sanitizing, and biannual property inspections (FDA, 2009). A study of raw milk used for cheese production in this country indicated a high quality and the variations observed regarding quality was related to the fact that some properties carry more strict hygienic measures (D'AMICO; DONNELLY, 2010).

It was observed that the increase in SCC was inversely related to cheese quality in the production of Manchego cheese type. In sensory evaluation, cheese graders noted rancid or lipase flavor in the highest level of SCC cheeses and they also deducted points for more body and texture defects in these cheeses at 6 and 9 months (JAEGGI et al., 2003). The low SCC scores in milk showed that it is possible to recover more than 4% of protein during cheese manufacturing, compared to milk with high counts (RAYNAL-LJUTOVAC et al., 2007). The high SCC appears as one of the most important parameters related to penalty for lower milk quality, since it can affect the quality of some dairies by the alteration of casein/whey protein proportion. The average discount on the amount paid for the milk over a year due to high SCC was 1.89% (ROMA JÚNIOR et al., 2009).

Evaluating the SPC, the percentage of samples under the maximum limits set by the current legislation increased between 2009 and 2010. Anyway, both counts have high values leading to low percentages of samples that comply with legal standards, demonstrating the difficulty of adequacy of producers in the region to the new requirements of Brazilian legislation, which aims to track the international market for dairy products.

A study conducted on small milk producers in Chile showed that the payment system according to milk quality resulted in lower scores compared to those observed in the Brazilian region studied. In this country, farmers are penalized for SPC above 100,000 CFU/mL (VAN SCHAIK et al., 2005), limit to be implemented in Brazil in 2016. The payment system for quality already deployed in the UK shows that stricter limit to be adopted in Brazil. In the UK, the payment is based on the geometric mean of the last three months. As the loss of payment of bonus entails severe financial consequences, there is a greater control of production (GREEN et al., 2006). According to official statistics of this country, the milk produced showed an increase in the average amount of fat compared to those seen in 2009, but the same did not happen with the average content of protein (DEFRA, 2012).

In Table 2 were observed statistically significant variations in levels of lactose and SNF in the range up to 6.0 x 10^5 cells/mL in both years when compared to other groups. The results indicate that there was a gradual increase in the levels of fat, due to the increase in the intervals of SCC, a fact also noted by other authors (GARGOURI; HAMED; ELFEKI, 2008; GUO et al., 2010; TSENKOVA et al., 2001). A study in Tunisia ranked the parameters within ranges and higher SCC was also observed increased levels of fat, due to the increase of the counts. According to these authors, for SCC scores below 1.0 x 10^6 cells/mL, mean fat were 3.28 and between 3.60% and 3.75% for the ranges above this count (GARGOURI; HAMED; ELFEKI, 2008). The fat values cited were therefore lower than those observed in this study between 3.93 and 4.01% to SCC intervals smaller than 1.0 x 10^6 cells/mL and 4.00 and 4.14% above this count.

Authors noted an increase in the extent of lipolysis and an increase in fat content as increased milk SCC, which can contribute to rancidity of refrigerated milk (GARGOURI; HAMED; ELFEKI, 2008). It was suggested that cells present in milk could be responsible for lipolysis of the triglycerides present in globules of milk fat, leading to the release of free fatty acids related to changes in milk taste and smell. The most important correlation with lipolysis

was observed in milk with a high percentage of polymorphonuclear lymphocytes (GARGOURI; HAMED; ELFEKI, 2008).

The major proteinase in milk is the plasmin that is associated with the casein micelles and acts primarily on the β-casein (PEREIRA et al., 2008; RAYNAL-LJUTOVAC et al. 2007). In the mammary gland of animals having high SCC it may occur acceleration on the conversion of plasminogen to plasmin and it may not be observed an increase in the content of plasminogen activator in the mammary gland (LEITNER et al., 2004). As the plasminogen is involved in the synthesis of casein (BUSETTI, 2006), acceleration in its conversion to plasmin would cause changes in the structure and composition of the casein micelle and leave the fat globule more susceptible to attack by lipases and thus to increase lipolysis (ABENI et al., 2005; RAYNAL-LJUTOVAC et al., 2007). Already an increase in the fat content could be attributed to the reduction in the volume of milk produced in the case of animal damage in mammary epithelial cells (GARGOURI; HAMED; ELFEKI, 2008). Thus, the increase in SCC in milk led to an increase in the assessed amount of fat (Table 2), but it could be causing the loss of quality milk and change in this fraction, which would undermine its conservation and industrialization.

In the case of protein, the changes were smaller between intervals and years. In general, there was a pattern of variation in protein content as a function of increase or decrease in SCC. In a study conducted in Israel, was also not observed influence of SCC on the concentration of protein in milk, but increased proteolysis of casein. Depending on the type of bacteria causing the infection, the plasmin activity in milk produced by the infected gland increased twice compared to uninfected animals (LEITNER et al., 2006). The biochemical proteolysis is an important event that provides impact on the taste and texture of most types of cheese and other dairy products, and may even lead to the release of compounds which alter the taste of the product (SOUSA; ARDÖ; McSWEENEY, 2001), but also the change in milk protein could lead to changes in the coagulation process and losses in processing.

One study evaluated the contents of fat and protein compared with SCC throughout lactation, noting that cows showed an increase in fat and protein content during peaks of SCC (WINDIG et al., 2005), a fact observed here only for fat content. In cheeses made with milk containing high SCC, it was observed an increase in the time needed for clotting and to obtain the clot firmness, loss in income, increase in water content, a higher intensity of lipolysis and proteolysis, and loss of sensory quality (JAEGGI et al., 2003; RAYNAL-LJUTOVAC et al., 2007).

The present study showed a gradual decrease in the levels of lactose due to increases in SCC, a fact reported by other authors (LEITNER et al., 2006; LINDMARK-MANSSON et al., 2006). Similarly, a study concluded that the lactose content was negatively correlated with the SCC and that the monitoring of this parameter could be a useful indicator of the quality of milk (LINDMARK-MANSSON et al., 2006).

SNF values did not correlate with intervals of SCC, a fact also observed in other studies (GARGOURI; HAMED; ELFEKI, 2008). Mean values were much higher than those found in bovine milk produced in Tunisia, where the percentages ranged between 7.1 and 7.6 for different intervals SCC (GARGOURI; HAMED; ELFEKI, 2008). The payment system for solids applied in some dairy from the Western part of Santa Catarina may contribute to the increase in SNF, since it generates a bonus in the price paid to producers.

SPC values were all over the limits established by Brazilian legislation for all ranges of SCC in the two years evaluated. The high contamination by unwanted microorganisms in milk affects its composition and influences the growth of unwanted bacteria in the process of cheese ripening. This is due to competition for nutrients and leads to changes in product quality attributes, such as color and texture, odors, unpleasant taste, changing the nutritional composition and gas production. There are also data related to proteolysis in cheese intense and may even be due to the presence of excessive lactic acid bacteria (RAYNAL-LJUTOVAC et al., 2007).

Studies have shown that dairy farm management and herd size play considerable influence on SCC and SPC in refrigerated milk. Some measures such as the use of automatic milking, dip teats for sanitization instead of spraying before and after milking also helps to decrease SCC e SPC counts (JAYARAO et al., 2004). Another study showed that reducing the total bacterial count and increase the milk quality can be obtained with some practices such as the

use of metal buckets for milking, examination of udder before milking, milking of animals suspected of mastitis, testing for mastitis and disposal of contaminated milk (VAN SCHAIK et al., 2005).

High values of SCC and SPC indicated that producers need to monitor their herds and they also need help regarding technical guidance in order to improve milk quality. Considering the reality of companies and local cooperatives, there is a clear concern with paying for quality. These levels, mainly of protein and fat, have a direct influence on the performance of dairy products and reflect in higher profitability. As for somatic cell counts and total bacterial, highlights the difficulty that the region will have to meet the quality standards required in the country and, consequently, that Brazil will face to meet international demands and become competitive in the global dairy market.

Conclusions

Milk produced in Western Santa Catarina submitted to SCC and SPC analysis showed exceeded limits, beyond those established by Brazilian legislation, which could result on an exclusion of several producers. The assessment on physico-chemical parameters in milk showed that the increase in SCC influences the contents of some components such as fat and protein. However the increase in SCC could also be associated with the presence of pathogens in animals, contamination of raw milk and its derivates, and less stability and shorter shelf life of the product. The survey data indicates that strict limits established in the legislation can be achieved only when it is accompanied by a job coach to guide the producer and herd management.

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