Akademik Ziraat Dergisi 9(1): 163-170 (2020)
ISSN: 2147-6403 e-ISSN: 2618-5881 DOI: http://dx.doi.org/10.29278/azd.725884

Research
(Araştırma)

Effects of some environmental factors on somatic cell count and milk chemical composition in cow bulk tank milk*

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*This research was carried out from a part of M.Sc. thesis of the first author. The study was presented as an oral presentation in the 11th International Animal Science Conference.

Alınış tarihi: 23 Nisan 2020, Kabul tarihi: 15 Haziran 2020
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Abstract

The aim of our research was to determine the influences of some environmental factors on somatic cell count (SCC) and chemical composition of cow bulk tank milk. A total of 428 bulk tank milk samples of Brown Swiss cows were collected between January and October 2016 from family dairy farms located in Kırşehir province of Turkey. To evaluate the effect of farm scale, daily total bulk tank milk production was classified in three groups (small: <20 lt/d; medium: 20-40 lt/d and large: >40 lt/d). Also, three groups were designed according to average SCC values as low (<200x10^3 cells/ml), medium (200-500x10^3 cells/ml) and high SCC (>500x10^3 cells/ml). SCC was transformed according to the base of log10, because it did not show normal distribution. The results showed that sampling season was significantly affected fat content (P<0.05), logSCC, solids-not-fat (SNF), protein, lactose and pH (P<0.01). SCC was the highest in large-scale farms, while the highest fat content was determined in small-scale farms (P<0.01). Also, the lowest pH was found in large-scale farms compared to small and medium-scale farms (P<0.01). Of all bulk tank milk composition, SCC only affected fat content (P<0.05), and the lowest fat content was determined in bulk tank milk with high SCC (>500x10^3 cell/ml). As a result, it was concluded that season was primarily responsible among the most important environmental factor to increase bulk tank milk quality.

Key words: Tank bulk milk, Somatic cell count, Milk composition, Bovine milk

İnek tank sütünde somatik hücre sayısı ve sütün kimyasal bileşimi üzerine bazı çevresel faktörlerin etkileri

Öz

Araştırmamızın amacı, somatik hücre sayısı (SHS) ve inek tank sütünün kimyasal bileşimi üzerine bazı çevresel faktörlerin etkilerini belirlemektir. Türkiye'de Kırşehir ilinin bulunan aile tipi süt sığırı işletmelerinden Ocak ve Ekim 2016 tarihleri arasında Esmer ineklerden toplam 428 adet tank inek sütü örneği toplanmıştır. İşletme ölçeğinin etkisini değerlendirmek için, günlük tank sütü üretimi üç grupta sınıflandırıldı (küçük: <20 lt/g; orta: 20-40 lt/g ve büyük: >40 lt/g). Ayrıca, ortalama SHS değerlerine göre düşük (<200x10^3 hücre/ml), orta (200-500x10^3 hücre/ml) ve yüksek SHS (>500x10^3 hücre/ml) olarak üç grup oluşturulmuştur. SHS normal dağılım göstermediği için log10 tabanına göre transforme edilmiştir. Sonuçlar, örnek alma mevsiminin yağ oranı (P<0.05), logSHS, yağsız kuru madde (YKM), protein, laktoz ve pH'ı (P<0.01) önemli ölçüde etkilediğini göstermiştir. SHS büyük ölçekli işletmelerde en yüksek iken, en yüksek yağ oranı küçük ölçekli işletmelerde belirlenmiştir (P<0.01). Ayrıca, en düşük pH küçük ve orta ölçekli çiftliklere kıyasla büyük ölçekli işletmelerde bulunmuştur (P<0.01).

Tüm tank sütü bileşimlerinden, SHS yalnızca yağ oranını etkilemiş (P<0.05) ve en düşük yağ oranı yüksek SHS (>500x10^3 hücre/ml) olan tank sütünde belirlenmiştir. Sonuç olarak, mevsimin tank süt kalitesini artırmak için öncelikle en önemli çevresel faktörlerden biri olduğu sonucuna varılmıştır.

Anahtar kelimeler: Tank sütü, Somatik Hücre sayısı, Süt bileşenleri, İnek sütü

Introduction

Milk is a unique biological fluid with high nutritional value. The quality of dairy products largely depends on the composition of raw milk. Therefore, the factors responsible for the variations in the composition and physico-chemical properties of raw milk are of paramount importance for milk processors (Ivanov et al., 2017). The recording of milk composition is essential for the dairy industry and the management of dairy farms (Najafi et al., 2009). Composition refers to the milk´s content of major nutrients such as fat, protein, lactose and total solids and somatic cell count (SCC) which is an indicator of udder health status (Guo et al., 2010) and milk quality (Sert et al., 2016).

The increase in milk SCC has also been associated with changes in bovine milk components (Garcia et al., 2015; Macedo et al., 2018). Due to the increase of SCC of milk in response to intramammary infection, milk quality is reduced because of change in the chemical composition of milk by lowering casein, lactose, calcium, and an increase of sodium, chloride and serum proteins (Pitkala et al., 2004).

Milk composition is affected by breed, age, number of lactations, the phase of lactation and other environmental factors. Therefore, all factors should be considered when we search the reasons for changes in milk composition. The effects of seasonal variation on milk yield and composition have been investigated by many researchers (Roma Júnior et al., 2009; Yang et al., 2013; Maha et al., 2016). Ozrenk and Inci (2008) determined that fat and protein content have been influenced by the sampling seasons. Pavel and Gavan (2011) reported that the amount of milk fat and protein in milk were negatively affected by environmental temperature.

Accurate estimates of changes in milk composition due to increase in SCC can be an incentive for breeders to consider the effects of such disorders in selection index by allocating appropriate economic weights. At this context, controlling mammary infections in dairy cows may be seen to be essential to achieve quality milk. In Turkey, the effect of different factors affecting the composition and quality of bulk tank milk have not been detailed investigated. Therefore, the aim of this study was to determine the influence of some environmental factors on SCC and the composition of bulk tank cow's milk.

Materials and methods

The milk samples were collected four times with three-month intervals during morning milking between January and October 2016 from Brown Swiss cows raised at family dairy farms in situated central of Kırşehir province. This region is located at 38 ° 50'-39 ° 50 ' north latitudes and 33 ° 30'- 34 ° 50' east latitudes and situated in the Middle Anatolian region of Turkey. The average altitute is approximately 985 meters above sea level. The winters are cold and hard, and the summers are generally hot and dry. Annual temperature average was 11.3 °C and ranged from 0.8 to 21.8 °C during in winter and summer.

The dairy cows in studied area were mainly fed roughages-dry straw and silage and drank ground water. All animals received the total mixed ration (TMR) and the herds were milked twice a day. In this study, cows were housed in tie stall. Additionally, farms had a mobile milking machine. In farms, cows had access to pasture during summer.

Daily raw bulk milk was measured with electronic flow milk meters. The samples were collected in sterile bottles of 50 mL without preservative and kept in +4°C until transported to the laboratory, then analyzed within 5–6 h of collection. The SCC was performed with the portable DeLaval Cell Counter DCC (DeLaval, Tumba, Sweden). The bulk milk components (fat, solids non-fat (SNF), protein and lactose) were determined by using the Lactostar auto milk analyzer (Funke-Gerber, Labortechnik, Article No 3510, Berlin, Germany). A total of 428 raw milk samples were analyzed. The actual SCC was transformed by using a log10 transformation to ensure homogeneity and normality of the variance.

The fixed effects of the model were sampling season, farm scale and SCC level. Sampling procedure was repeated four times in same condition at four seasons. Four sampling season subgroups were formed according to test date: 1=Autumn (October); 2= Winter (January); 3= Spring (April); 4= Summer (July). The dairy farm scale on SCC and milk components in experimental days were investigated by categorizing daily total bulk tank milk production into three groups; small: <20 lt/d, medium: 20-40 lt/d and large: >40 lt/d. Milk samples were assessed into three groups according to their average SCC values: low (<200x10^3 cells/ml), medium (200-500x10^3 cells/ml) and high SCC (>500x10^3 cells/ml).

Data were analyzed by using SPSS 17 packet program. Differences among the subgroups were performed using Duncan's Multiple Range Test.

Results and Discussion

Descriptives of the collected milk quality parameters are seen in Table 1. Wide variations between the thresholds of the parameters especially for SCC was found to be attractive. Therefore, SCC were transformed by using a log10 transformation. Besides, the overall of untransformed SCC was calculed to be 624224 cells/ml and this value might be assumed as unsuitable to EU directives because of higher than limits in many other countries including the European Union (400x10^3 cells/ml) (Hillerton and Berry, 2004) and the threshold value specified by the Turkish Food Codex is >500x10^3 cells/ml (Anonymous, 2000). The results of ANOVA are given in Table 2.

In this study, the season had significant effect ($P<0.01$) on logSCC (Table 2). LogSCC was the highest in summer and the lowest in winter (Table 3), which is consistent with previous studies (El-Tahawy and El-Far, 2010; Pavel and Gavan, 2011; Maciuc et al., 2017). The authors attributed the higher average in the summer to stress due to high temperatures and humidity exposing animals to a greater number of pathogens and increasing susceptibility to infections and occurrence of mastitis (Simioni et al., 2014; Ribas et al., 2014). Also, according to Harmon (1994) some stressors, especially heat, may increase SCC in milk. However, Vasconcelos et al. (1997) found no difference in SCC between milk samples collected in summer and winter.

In the present study, fat content of bulk tank milk was significantly higher in autumn and the lowest in spring and summer. Significantly higher protein content was observed in spring and winter compared with autumn and summer ($P<0.05$). Similar to present study, Simioni et al. (2014) determined that the autumn season had the highest fat content, while the winter season showed the highest protein content. Similar finding was also reported by Maciuc et al. (2017) who determined that protein and fat in milk were higher during cold months. Chandan (2006) found 10% variation for both fat and protein in milk with lowest levels in summer. Also, Maha et al. (2016) detected that protein content was constantly lower during autumn compared to spring and winter. This was probably due to lower intake of feed energy with in-door feeding and may reflect the feeding regime used for herds (Maha et al., 2016). Another factor that could explain the lower concentration of fat and protein content in the summer would be the presence of lipases leukocyte metabolizing fatty acids in milk and leukocyte proteases that could cause a significant reduction on casein (Simioni et al., 2014). Besides, spring grass or pasturing may have a specific transient and beneficial effect on milk protein (Agabriel et al., 1993).

Table 1. Description of the milk quality parameters

	Mean	SD	Min	Max
SCC, *cells/ml*	624224	819747	22000	4856000
LogSCC	5.53	0.49	4.34	6.69
Fat, %	3.68	0.63	2.07	5.81
SNF, %	8.90	0.43	7.0	9.99
Protein, %	3.27	0.18	2.56	3.90
Lactose, %	4.84	0.25	4.14	5.69
pH	6.63	0.22	5.85	6.97

LogSCC: logarithmic somatic cell count; SNF: solids-not-fat

SD: Standard Deviation; Min: minimum value; Max: maximum value

Table 2. The ANOVA of milk quality parameters

	Season	Farm scale	SCC levels
LogSCC	**	**	*
Fat, %	*	**	ns
SNF, %	**	ns	ns
Protein, %	**	ns	ns
Lactose, %	**	ns	ns
pH	**	**	ns

**P<0.01; *P<0.05; ns: non-significant

logSCC: logarithmic somatic cell count; SNF: solids-not-fat

Table 3. Effects of sampling season and farm scale on somatic cell count and milk composition

Season	n	LogSCC	Fat	SNF	Protein	Lactose	pH
Winter	108	5.38[c]	3.67[ab]	8.96[ab]	3.29[a]	4.87[ab]	6.76[a]
Spring	123	5.50[b]	3.61[b]	8.99[a]	3.31[a]	4.90[a]	6.33[c]
Summer	90	5.77[a]	3.63[b]	8.77[c]	3.22[b]	4.77[c]	6.73[ab]
Autumn	107	5.50[b]	3.83[a]	8.85[bc]	3.24[b]	4.81[bc]	6.71[b]
Farm scale							
Small	139	5.45[b]	3.84[a]	8.89	3.26	4.83	6.66[a]
Medium	166	5.52[b]	3.66[b]	8.91	3.27	4.84	6.67[a]
Large	123	5.63[a]	3.53[b]	8.91	3.27	4.85	6.54[b]

[a-c] Differences between different superscript in the same column is significant

LogSCC: logarithmic somatic cell count, SNF: solids-not-fat

Small: <20 lt/d; Medium: 20-40 lt/d and Large: >40 lt/d

In the current study, both SNF and lactose were the highest in spring, but the lowest in summer. Our results also are consistent with the findings reported by Dobranić et al. (2008), who determined that lactose was the highest in spring and winter while SNF was significantly lower in the summer. Noro et al. (2006) found higher levels of protein and lactose in the winter, attributing this result to feeding with temperate grasses. Decline of lactose content can be accompanied by reduction of solids, which could be observed in this study. On contrary to our results, Roma Júnior et al. (2009) observed higher values for protein during autumn. Pavel and Gavan (2011) explained that the change of main milk components in different seasons caused by different ingestible diets. pH was significantly different between the seasons (P<0.001). As seen in Table 3, pH was the highest in winter, and the lowest pH was in spring. Kul et al. (2018) reported that the highest pH was determined in spring, but lowest in autumn season (P<0.01). These results are disagree with those of Ozrenk and Inci (2008) and Syridion et al. (2012) who emphasized that effect of seasons on pH was no significant.

Duncan's multiple comparisons of farm scales (Table 3) indicated that logSCC in the bulk tank milk obtained from in large-scale farms was lower than in small and medium-scale farms. This is an indication of poor udder hygiene controlling and preventing mastitis due to a lack of labor investment and limited training of employees in large-scale farms (Vu et al., 2016). Therefore, the milking management and sanitary conditions in large farms were should be improved. This result was not in accordance with result of Ivanov et al. (2017) reported that SCC are significantly higher in the bulk milk obtained in small-scale farms than in the milk from large-scale farms.

In present study, fat content was determined to be higher in small-scale farms than medium and large-scale farms (P<0.01) probably due to the different feeding regyme. pH was the lowest in large-scale farms. No statistically significant difference was found in SNF, protein and lactose contents in the bulk tank milk obtained from different scale farms. This might be related to the rearing similar cow breed in the evaluated farms.

Table 4. Effects of SCC levels on milk composition

SCC levels	n	Fat	SNF	Protein	Lactose	pH
Low	131	3.66^{ab}	8.91	3.27	4.85	6.61
Medium	151	3.78^{a}	8.92	3.27	4.84	6.65
High	146	3.60^{b}	8.88	3.26	4.83	6.63

a-b Differences between different superscript in the same column is significant; SCC: somatic cell count; SNF: solids-not-fat; low: SCC<200x10^3 cells/ml, medium: SCC=200-500x10^3 cells/ml, high: SCC>500x10^3 cells/ml

Fat content was significantly affected by SCC level (P<0.05). Fat content decreased with increasing SCC, and fat content was the lowest in bulk tank milk with SCC>500x10^3. However, effect of SCC levels on pH, SNF, protein and lactose content were not significantly important (Table 4). When the SCC increased, it was seen that fat content decreased (P<0.05), whereas pH, SNF, protein and lactose milk protein, milk fat and total solids decreased, though these differences were not significant. Our results revealed that fat content decreased with increase in SCC, which were similar with the results of Najafi et al. (2009). Also, the changes in fat with different SCC have been reported (Noro et al., 2006; Garcia et al., 2015; Macedo et al., 2018). This could be related to the decrease of fat synthesis by epithelial cells in mammary gland (Fernandes et al., 2004). In contrast, some researchers determined no significant reduction in fat with high SCC (Moslehishad et al., 2010; Cinar et al., 2015). No relationship between protein content with SCC was similar to earlier studies (Albenzio et al., 2005; Sun et al., 2009; Garcia et al., 2015). However, the result of present study was not in agreement with the findings of Jaeggi et al. (2003), who determined the lowest protein content observed in bulk tank milk with highest SCC. On contrary to our results, Garcia et al. (2015) and Sobczuk-Szul et al. (2015) reported that lactose with increasing SCC in milk decreased. Different result was reported by Ribas et al. (2014), as they observed SNF with increasing SCC increased. Macedo et al. (2018) also found that SNF were higher in herds with SCC threshold higher than 250x10^3 cells/ml. Variation in the diffrent results may be due to differences in diet, parity and season of the experiment, management, etc.

The acceptable SCC value for high quality fresh milk is ≤400x10^3 cells/ml. However, in present study, the overall SCC of bulk tank milk was calculated to be higher than 500x10^3 cells/ml (Table 4). The high bulk tank milk SCC in these farms is the result of inadequate hygiene and management practices to reduce SCC. Therefore, dairy farmers should improve environmental and management factors, such as feeding strategies, housing conditions and milking procedures to gain more quality raw milk.

Table 5. Correlations coefficients among investigated parameters

	Fat	SNF	Protein	Lactose	pH
SCC	-0.138	0.003	0.018	0.003	0.057
Fat		0.061	0.031	0.018	0.114
SNF			0.964	0.938	-0.151
Protein				0.916	-0.169
Lactose					-0.191

SCC: somatic cell count, SNF: solids-not-fat

From shown results (Table 5), the correlation (r=-0.138) between SCC and fat content was determined as negative. However, positive correlations were found between SCC with SNF, protein and lactose contents and pH. The negative correlation between SCC and fat content was well documented by many authors (Najafi et al., 2009; Guo et al., 2010). Differently, Kuczaj (2001) determined no significant correlation (0.130) between SCC and fat content. Also, several studies reported a positive correlation between SCC and fat (Rajčevič et al., 2003; Macedo et al., 2018). Further, results of this study were consistent with those of Kuczaj (2001) and Macedo et al. (2018), who reported positive correlation between SCC and protein content. pH had positive correlation between fat content (r=0.114), while negatively correlations with protein content (r=-0.169) and lactose (r=-0.191). High correlations between SNF with protein (r=0.964) and lactose content (r=0.938) were positively. Positively and high correlation (r=0.916) between protein and lactose were observed.

Conclusions

The results showed that the season had a significant effect on SCC and bulk tank milk composition. The present study has strongly indicated that logSCC was higher in summer, fat content was higher in autumn, pH was higher in winter, and SNF, protein and lactose content showed the highest in spring. The highest logSCC was determined in bulk tank milk obtained from large-scale farms, while the highest fat content was determined in small-scale farms. Also, the lowest pH value was found in large-scale farms compared to other farm scales. High SCC was negatively affected only milk fat content. The lowest fat content was determined in bulk tank milk with SCC higher than $500x10^3$ cells/ml. It was concluded that season is primarily responsible among the evaluated environmental factors to increase bulk tank milk quality.

Thank

We are also greatful to Emre Uğurlutepe and Mustafa Soydaner for their valuable assistances.

References

Agabriel, C., Coulon, J. B., Marty, G., & Bonaiti, B. (1993). Changes in fat and protein concentrations in farms with high milk production. *Journal of Dairy Science*, 76(3), 734-741.

Albenzio, M., Caroprese, M., Santillo, A., Marino, R., Muscio, A., & Sevi, A. (2005). Proteolytic patterns and plasmin activity in ewes' milk as affected by somatic cell count and stage of lactation. *Journal of Dairy Research,* 72(1), 86-92.

Anonymous (2000). *Turkish food codex regulation, Notification No. 2000/6 on raw and UHT milk*. Official Journal, Number, 23964, 14 February 2000.

Chandan, R. (2006). *Manufacturing yogurt and fermented milks*. Blackwell Publishing Lowa, USA.

Cinar, M., Serbester, U., Ceyhan, A., and Gorgulu, M. (2015). Effect of somatic cell count on milk yield and composition of first and second lactation dairy cows. *Italian Journal of Animal Science, 14*(1), 3646.

Dobranić, V., Njari, B., Samardžija, M., Mioković, B., & Resanović, R. (2008). The influence of the season on the chemical composition and the somatic cell count of bulk tank cow's milk. *Veterinarski Arhiv, 78*(3), 235-242.

El-Tahawy, A. S., & El-Far, A. H. (2010). Influences of somatic cell count on milk composition and dairy farm profitability. *International Journal of Dairy Technology, 63*(3), 463-469.

Fernandes, A. M., Oliveira, C. D., & Tavolaro, P. (2004). Relationship between somatic cell counts and composition of milk from individual Holstein cows. *Arquivos do Instituto Biológico, 71*(4), 163-166.

Garcia, R. R., Maion, V. B., de Almeida, K. M., de Santana, E. H. W., Costa, M. R., Fagnani, R., & Ludovico, A. (2015). Relationship between somatic cell counts and milk production and composition in Jersey cows. *Revista de Salud Animal, 37*(3), 137.

Guo, J. Z., Liu, X. L., Xu, A. J., & Zhi, X. I. A. (2010). Relationship of somatic cell count with milk yield and composition in Chinese Holstein population. *Agricultural Sciences in China, 9*(10), 1492-1496.

Harmon, R. J. (1994). Physiology of mastitis and factors affecting somatic cell counts. *Journal of Dairy Science, 77*(7), 2103-2112.

Hillerton, J. E., & Berry, E. A. (2004). *Quality of the milk supply: European regulations versus practice*. Proc. of 43rd Annual Meeting of the National Mastitis Council, p. 207-214.

Ivanov, G. Y., Bilgucu, E., Balabanova, T. B., Ivanova, I. V., & Uzatici, A. (2017). Effect of animal breed, season and milk production scale on somatic cell count and composition of cow milk. *Bulgarian Journal of Agricultural Science*, *23*(6), 1047-1052.

Jaeggi, J. J., Govindasamy-Lucey, S., Berger, Y. M., Johnson, M. E., McKusick, B. C., Thomas, D. L., & Wendorff, W. L. (2003). Hard ewe's milk cheese manufactured from milk of three different groups of somatic cell counts. *Journal of Dairy Science, 86*(10), 3082-3089.

Kuczaj, M. (2001). Interrelations between year season and raw milk hygienic qualiry indices. Series Electronic Journal of Polish Agricultural Universities. *Animal Hasbandry*, *4*(1), 1-7.

Kul, E., Sahin, A., Ugurlutepe, E., Soydaner, M., & Özlem, O. (2018). Milk somatic cell count and pH as an indicator of udder health status in Holstein cows. *Advances in Food Sciences*, *40*(2), 76-80.

Macedo, S. N., Gonçalves, J. L., Cortinhas, C. S., Leite, R. F., & Santos, M, V. (2018). Effect of somatic cell count on composition and hygiene indicators of bulk tank milk. *Brazilian Journal of Veterinary Research and Animal Science*, *55*(1), 1-11.

Maciuc, V., Radu-Rusu, C. G., Popescu, E. C., Radu-Rusu, R. M., & Jurco, E. C. (2017). Influence of season and cows farming system on milk physical, chemical and hygienic traits. *Romanian Biotechnological Letters*, *22*(6), 13108-13119.

Maha, E. H., Linda, Z., Abdellah, E. H, Mohamed, B., Ahmed, D., Abdelmajid, Z., Khadija, O., & Mohammed, B. (2016). Seasonal effect on bovine raw milk composition of oulmes local race in Morocco. *Food Science and Quality Management*, *52*, 49-55.

Moslehishad, M., Ezzatpanah, H., & Aminafshar, M. (2010). Chemical and electrophoretic properties of Holstein cow milk as affected by somatic cell count. *International Journal of Dairy Technology*, *63*(4), 512-515.

Najafi, M. N., Mortazavi, S. A., Koocheki, A., Khorami, J., & Rekik, B. (2009). Fat and protein contents, acidity and somatic cell counts in bulk milk of Holstein cows in the Khorasan Razavi Province, Iran. *International Journal of Dairy Technology*, *62*(1), 19-26.

Noro, G., González, F. H. D., Campos, R., & Dürr, J. W. (2006). Effects of environmental factors on milk yield and composition of dairy herds assisted by cooperatives in Rio Grande do Sul, Brazil. *Revista Brasileira de Zootecnia*, *35*(3), 1129-1135.

Ozrenk, E., & Inci, S. S. (2008). The effect of seasonal variation on the composition of cow milk in Van province. *Pakistan Journal of Nutrition*, *7*(1), 161-164.

Pavel, E. R., & Gavan, C. (2011). Seasonal and milking-to-milking variations in cow milk fat, protein and somatic cell counts. *Notulae Scientia Biologicae*, *3*(2), 20-23.

Pitkala, A., Haveri, M., Pyorala, S., Myllys, V., & Honkanen-Buzalski, T. (2004). Bovine mastitis in Finland 2001-prevalence, distribution of bacteria, and antimicrobial resistance. *Journal of Dairy Science*, *87*(8), 2433-2441.

Rajčevič, M., Potočnik, K., & Levstek, J. (2003). Correlations between somatic cells count and milk composition with regard to the season. *Agriculturae Conspectus Scientificus*, *68*(3), 221-226.

Ribas, N, P., Junior, P. R., Monardes, H. G., Andrade, U. V. C., Valotto, A. A., & Regonato, D. (2014). Bulk tank somatic cell count in milk samples from state of Paraná. *Archives of Veterinary Science*, *19*(1), 70-78.

Roma Júnior, L. C., Montoya, J. F. G., Martins, T. T., Cassoli, L. D., & Machado, P. F. (2009). Seasonability of protein and others milk components related with quality payment program. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *61*(6), 1411-1418.

Sert, M., Mercan, M., Aydemir, S., & Civelek, M. (2016). Effects of milk somatic cell counts on some physicochemical and functional characteristics of skim and whole milk powders. *Journal of Dairy Science*, *99*, 5254-5264.

Simioni, F. J., Lopes, L. S., Nespolo, C. R., Stefani, L. M., Bordignon, R., & Bittelbrun, M. S. (2014). Season influence on milk physico-chemical and microbiological aspects in Western Santa Catarina. *Semina: Ciências Agrárias*, *35(4)*, 2033-2046.

Sobczuk-Szul, M., Wielgosz-Groth, Z., Nogalski, Z., Mochol, M., Rzemieniewski, A., & Pogorzelska-Przybyłek, P. (2015). Changes in the fatty acid profile of cow's milk with different somatic cell counts during lactation. *Veterinarija ir Zootechnika*, *69*(91), 52-57.

Sun, Y., Niu, L. X., Zhang, Y. L., & Gao, T. Y. (2009). Change patterns of SCC in milk of dairy cows and its relationship with composition. *Animal Husbandry and Feed Science*, *30*, 133-134.

Syridion, D., Layek, S. S., Behera, K., Mohanty, T. K., Kumaresan, A., Manimaran, A., Dang, A. K., & Prasad, S. (2012). Effects of parity, season, stage of lactation, and milk yield on milk somatic cell count, pH and electrical conductivity in crossbred cows reared under subtropical climatic conditions. *Milchwissenschaft*, *67*(4): 362-365.

Vasconcelos, C. G. C., Nader, A., Amaral, L. A., & Pereira, G. T. (1997). Influence of the season of the the year, stage of lactation and milking time on somatic cell counts in bovine milk. *Arquivo Brasileiro De Medicina Veterinaria E Zootecnia*, *49*(4), 483-491.

Vu, N. H., Lambertz, C., & Gauly, M. (2016). Factors influencing milk yield, quality and revenue of dairy farms in Southern Vietnam. *Asian Journal of Animal Sciences*, *10*(6), 290-299.

Yang, L., Yang, O., Yi, M., Pang, Z. H., & Xiong, B. H. (2013). Effects of seasonal change and parity on raw milk composition and related indices in Chinese Holstein cows in northern China. *Journal of Dairy Science*, *96*, 6863–6869.