Influence of Electrical Conductivity, Days in Milk and Parity on Milk Production and Chemical Composition

Radu Neamț[1]*, Daniela Elena Ilie[1], Dinu Gavojdian[1], Stelian Acatincăi[2], Neciu Florin[1], Ludovic Cziszter[1,2]

[1.]Research and Development Station for Bovine, 310059, Arad, Calea Bodrogului 32, Romania
[2.]Banat´s University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara, Faculty of Animal Science and Biotechnologies, 300645, Timisoara, Calea Aradului 119, Romania

Abstract

The aim of study was to assess milk production and chemical composition during the first 100 days of lactation, under the influence of electrical conductivity, parity and days in milk. Study was conducted at Research and Development Station for Bovine Arad, on 66 Romanian Spotted cows (20 primiparous, 46 multiparous). Significantly higher values ($p \leq 0.017$) of electrical conductivity were recorded for primiparous (10.15±0.09 mS/cm) compared with multiparous (8.79±0.15 mS/cm). During the first 30 DIM electrical conductivity was higher (9.7±0.12 mS/cm) than for 31 to 60 DIM (9.04±0.12 mS/cm; $p \leq 0.001$) and for 61 to 100 DIM (8.17±0.11 mS/cm, $p \leq 0.001$). Multifactorial regression model applied highlights significant influence of month of calving ($p \leq 0.001$) and DIM ($p \leq 0.034$) on the electrical conductivity, while parity had no influence ($p > 0.36$). Medium and negative correlations were calculated between electrical conductivity and some chemical components (fat R=-0.15, protein R=-0.13), while to milk production correlation was positive (R=0.12). No significant correlations were obtained according to lactose content (R=-0.013). Dynamics of milk production and chemical composition have been significantly influenced by month of calving ($p \leq 0.001$), DIM ($p \leq 0.001$) and parity ($p \leq 0.002$). This study found no significant influence of milk electrical conductivity on milk production or chemical composition ($p > 0.59$).

Keywords: cows, electrical conductivity, mastitis, milk.

1. Introduction

Mastitis is the mammary gland disorder with a significant impact on milk production and chemical composition. It is also the most frequent and costly disease in dairy herds. Studies conducted reveal productive and qualitative losses, reducing of current lactation (in some cases even the subsequent ones), impairment of reproductive patterns, leading often to increase the proportion of necessity culling in the dairy herd. Losses in dairy herds were estimated to 22% (Holstein–in France) and 19% (in Northern Ireland). Mastitis presents long-term residual effects. Reduction of milk production as well as the reduction of its chemical composition can be visible with 4-7 days before mastitis diagnostic and the effects could extend for 4-5 months [1]. The productive and qualitative losses registered under the influence of mastitis are significant. Seegers *et al.* (2003) show an average loss of 375 kg of milk for each relapse of mastitis during the current lactation [2]. A reduction of about 600 kg milk was recorded in the study performed by Wilson *et al.* (2004) [3]. Early detection of changes occurring in morphological and physiological mammary gland and timely intervention based on specific medical treatments, have the ability to significantly limit production losses and the mastitis persistence [4]. The incidence of mastitis reaches thresholds of 20-

* Corresponding author: Radu Neamt, neamtr@yahoo.com

40% in dairy herds, causing costs by 45% higher [5].

Constant and continuous evaluation of udder health could be a simple and efficient method to alert for farmers [6]. Livestock practice allows easy detection of mastitis based on a wide range of specific methods. Determining the number of somatic cells alongside with the specific bacteriological examination performed on samples of milk are reliable methods but due to their complexity do not allows the application of them as a daily routine [7]. The electrical conductivity of milk is a realistic indicator of udder health being introduced in specific assessments, accentuated in the last few decades [8].

According to other complex methods for monitoring the udder health, significant correlations were established (R=0.3-0.4), so the evaluation of milk electrical conductivity can be considered a method with high precision [9, 10]. Conducted in time, researches have demonstrated a strong association between the electrical conductivity of milk and presence of mammary infections [11, 12]. Moreover, the electrical conductivity of milk is a reliable and suitable in daily routine indicator for monitoring the udder health, early detection of mastitis and preventing economic loss. Evaluating the milk electrical conductivity, Ilie *et al.* (2010) has succeeded to accurately diagnose 81.4% of clinical mastitis and 44% of subclinical ones [13].

The risk of mastitis has a dynamic variability during lactation. An increased incidence was recorded during the first month of lactation and in primiparous cows [14]. The early period of lactation presents an increased risk of udder disease, with negative effects on the rate of milk ejection and the milk quantity and quality [15]. Occurrence of mastitis during the first 100 days of lactation has a long persistence on productive values, being the main cause of cow exits from herds (30-35% of cows) [16]. Bimodality of milk flow trait, under the influence of the lactation phase and the udder readiness for milking, are causes of mastitis occurrence [17].

Advancement in lactation leads to an increase in milk conductivity, by about 0.18 units/day. However, electrical conductivity of milk is under a significant influence of the ambient temperature, which causes increases by 0.01 units/day for each extra degree. Also, a decrease in milk production of about 0.018 kg/day was observed [6].

Significant decrease of milk production was recorded by 10-14 days before mastitis diagnosis, alongside with 8-10% increase of electrical conductivity of milk. Remanence of the situation has been assessed at approx. 60 days after healing [6]. Significant increase of milk electrical conductivity in case of mastitis was found by Murray *et al.* (1998) [18]. Negative effects of mastitis are recorded in milk chemical composition, milk flow traits as well as milking efficiency [19].

Increased electrical conductivity of the mastitis milk leads to a decreased fat content in milk [18, 20]. Analyses conducted on the dynamics of protein content in relationship with the electrical conductivity of milk show conflicting results. Estimation of protein content is based on milk nitrogen, whose levels increase significantly in mammary infections.

Analysing dynamics of casein, a decrease in the milk from mastitis infected cows was observed. This process runs intensively between daily milking, as well as during the milking, under the action of proteolytic enzymes [21, 22]. Mammary infections determine the reduction of the lactose content in milk [20]. Increased milk electrical conductivity determined by the presence of mammary infections leads to changes in milk *pH*. Studies conducted for that purpose by various research groups had yielded conflicting results. Mara *et al.* (1993) found an increase of milk pH in mastitis infections, results confirmed in studies conducted by Kaptan *et al* (2011) [23, 24]. In contradiction, studies conducted by Baljinder *et al.* (2005) found no significant differences in pH between the milk from healthy and mastitis infected cows [20].

Conducted in time, researches in this area reveals unequivocally interrelationship between the electrical conductivity of milk and presence of mastitis infections [25].

Norberg E. *et al.*, (2005, 2006) calculated (in successive studies) higher correlation coefficients for milk electrical conductivity in relation to the presence of mastitis infections R=0.65-0.8 [26, 27].

The electrical conductivity of milk can be introduced as a trait in the genetic improvement programs for resistance to mastitis.

High heritability coefficient of this trait has been highlighted by multiple studies. Heritability values are presented as medium to high. Norberg *et al.*

(2004, 2005, 2006) calculated heritability coefficients with values between 0.12 and 0.39 [12, 26, 27].

2. Materials and methods

The research activities were performed in accordance with the European Union's Directive for animal experimentation (Directive 2010/63/EU).

The study was carried out at the Research and Development Station for Bovine Arad, Romania (location: 46° 10' 36" N, 21° 18' 4" E, 107 m altitude, 582 mm annual average rainfall, 21°C/-1°C average temperature corresponding for summer/winter, with an annual average temperature of 10.5°C).

The aim of study was to assess milk production and chemical composition during the first 100 days of lactation, under the influence of electrical conductivity, parity and days in milk (DIM).

The animals from this farm were reared in a semi-intensive system, characterized by moderate growth rate in young stock (500-750 g/day) and moderate productive values for lactating cows (5500-6200 kg milk / normal lactation). Productive lifetime for lactating cows averages 5.2 lactations.

Cows are rearing in loose housing all year round. The milking was performed twice a day on a milking parlour (2x14 places).

Recording data regarding milk production and milk electrical conductivity was done automatically, individually, and separately for each milking session with Afimilk specialized software. Related data for chemical composition of milk (fat, protein, lactose) were recorded following the analysis performed by LactoStar multi-parameters analyser which is a device for analysis of milk, with the ability to determine precisely the fat, protein, and lactose percentage, density and freezing point of milk, the addition of water, pH and milk temperature.

Data was collected daily from a total of 66 Romanian Spotted cows, Fleckvieh type, 20 primiparous and 46 multiparous cows in different lactations (2 to 5). Data collected aimed I) daily milk production; II) fat content; III) protein content; IV) lactose content; V) electrical conductivity, corresponding to the first 100 DIM.

Dynamics of milk production and its chemical composition was evaluated under the influence factors included in the study I) milk electrical conductivity; II) calving month (August-October); III) DIM (1-30 DIM, 31-60 DIM, 61-100 DIM); IV) parity of cows (primiparous, multiparous). Data regarding somatic cell count (SCC) were collected individually based official performance control to be correlated with values of milk electrical conductivity. Based on SCC cows were classified as: I) clinically healthy ($SCC \leq 200x10^3$) II) subclinical mastitis ($SCC \leq 400x10^3$), III) clinical mastitis ($SCC > 400x10^3$).

Data were analysed used Statistica software (StatSoft) v. 13 [28]. Results were expressed as means (±standard error) used the Basic Statistics. Differences between groups of data were assessed using *t test*. Correlation coefficients were calculated for milk production and quality traits in relation to influence factors included in study, based on *Pearson* correlation. The influence level of factors has been established based on a multifactorial regression model. Multifactorial regression model was applied including different associations models of influential factors.

3. Results and discussion

Results expressed as average values and standard error of the mean for milk production, chemical composition, milk electrical conductivity according to the DIM, cow's parity, and SCC are presented in Table 1, Table 2 and Table 3, respectively.

Table 1. Means (±standard error) for milk production, chemical composition and electrical conductivity (EC) according to DIM

Parameters	DIM 1-30	DIM 31-60	DIM 61-100	*Average*
Milk (kg)	19.62 ± 0.52^a	17.62 ± 0.5^b	16.22 ± 0.56^c	*17.94±0.3*
Fat (%)	3.69 ± 0.11^a	4.16 ± 0.1^b	4.45 ± 0.07^c	*4.1±0.06*
Protein (%)	3.25 ± 0.04^a	3.32 ± 0.04^a	3.53 ± 0.04^b	*3.37±0.02*
Lactose (%)	4.82 ± 0.03^a	4.87 ± 0.03^a	4.92 ± 0.04^a	*4.87±0.02*
EC (mS/cm)	9.7 ± 0.12^a	9.04 ± 0.12^b	8.17 ± 0.11^c	*8.97±0.08*

Rows with different superscript differ significantly at $p \leq 0.05$

Table 2. Means (±standard error) for milk production, chemical composition and electrical conductivity (EC) according to cow's parity

Parity	Milk (kg)	Fat (%)	Protein (%)	Lactose (%)	EC (mS/cm)
Primiparous	*19.08±0.3*[a]	*4.11±0.15*[a]	*3.4±0.04*[a]	*4.80±0.02*[a]	*10.15±0.18*[a]
Multiparous	*18.90±0.4*[a]	*4.18±0.12*[a]	*3.4±0.03*[a]	*4.87±0.03*[a]	*8.79±0.19*[b]

Columns with different superscript differ significantly at *p≤0.05*

Table 3. Means (±standard error) for milk production, chemical composition and electrical conductivity (EC) according to SCC

SCC	SCC average	Milk (kg)	Fat (%)	Protein (%)	Lactose (%)	EC (mS/cm)
≤200x10^3	116x10^3	18.80±0.5[a]	4.5±0.08[a]	3.37±0.03[a]	4.98±0.02[a]	8.32±0.06[a]
201-400x10^3	308x10^3	18.12±0.5[a]	4.2±0.08[a]	3.36±0.04[a]	4.87±0.03[a]	9.80±0.07[b]
>400x10^3	591x10^3	16.00±0.4[b]	3.9±0.11[b]	3.14±0.06[b]	4.19±0.03[a]	12.03±0.05[c]

Columns with different superscript differ significantly at *p≤0.05*

Milk production decreases with advancing into lactation. Results showed an average value of 19.62±0.52 kg milk for first 30 DIM, which was significantly higher compared to values obtained in 31-60 DIM (17.62±0.5 kg milk, *p≤0.008*) and 61-100 DIM (16.22±0.56 kg milk, *p≤0.001*).

Milk production recorded for the first 30 DIM had the highest value compared to others two intervals of lactation. Associated with a high EC value, the milk production recorded a decreasing trend in lactation interval sequences. A similar trend was also recorded for EC Production losses were fast and pronounced due to increased value of milk EC in the early stage of lactation, results also obtained by Hammer *et al.* (2012) and Tancin *et al* (2006) [14, 15]. Increased value of milk EC recorded in the first 30 DIM was maintained throughout the entire study period, confirming the results obtained by Lukas *et al* (2009) [6]. The decreasing trend of milk production for the entire period of 100 DIM had a rate of 0.037 kg milk/day. In comparison, Kocak (2006) recorded a higher loss rate in Holstein cows (0.76-4.56 kg milk/day) particularly in confirmed clinical mastitis [29]. Even if milk EC decreased during the study period by 0.017 units/day, the high value recorded since the early stages of lactation makes its remanence on the productive level to be extended, confirming the results also obtained by Rajala *et al*. (1999) [30]. Increased levels of milk EC soon after calving, has induced a production loss rate by 16% in primiparous and a significantly reduced loss rate (5.4%) in multiparous cows. Values were higher compared with cases when a high milk EC had been installed in other phases of lactation, as demonstrated by Hagnestam *et al.* (2009) which recorded a loss rate between 3 and 9% for multiparous and 4 to 18% in primiparous cows [31]. Dynamics of milk EC in the sequence of lactation intervals included in this study can be explained based on milk chemical composition. Increased milk EC values immediately after calving is generally associated with an increased SCC, particularly in colostrum sub-period [32]. This is mainly due to the morphological structure of the udder characterized by a high sensitivity and permeability of the tissue.

Fat content increased significantly in relationship to DIM from 3.69±0.11% for 31-60 DIM to 4.16±0.1% for 61-100 DIM (*p≤0.003*) and to 4.45±0.07% for 61-100 DIM (*p≤0.001*). No significant differences were recorded for protein content between first and second interval of DIM (3.25±0.04% *vs.* 3.32±0.04%, *p>0.22*).

Dynamics of fat content evolves diametrically opposed in relation to milk EC Alongside decrease of milk EC by 0.017 units/day (15.77%) fat content significantly increased according to lactation intervals sequences (20.59%). Low fat content recorded in the first 30 DIM is corresponding to the available literature data [15, 18, 20]. Initial low milk fat content was followed by an increasing trend due to other causes such as parsimonious feeding, acidosis [33], ketosis [34] or lameness [35]. The present study recorded increases in fat content along with decreases in milk production, which is physiologically normal. By calculating the correlation coefficient between fat content and milk EC a negative and low value was recorded (R=-0.15), which raised the first question regarding the influence of EC on this parameter. A non-significant impact of EC on the fat content was showed by the multifactor regression model applied, regardless of potentially influence factors association (Table 4).

Table 4. Multifactorial regression model for fat content according to the influence factors association model

Parameter	EC	Month of calving	DIM	Parity
Fat content (%)	*p>0.14*	*p≤0.001*	*p≤0.001*	*p>0.08*
	p>0.54		*p≤0.001*	*p>0.45*
	p>0.62		*p≤0.001*	

Significantly at *p≤0.05*

According to the multifactorial regression model employed, the month of calving and DIM had a significant influence on the milk fat content, which confirm the results obtained by Masoud *et al.* (2009) [36]. Although some studies found an increase of fat content in milk from mastitis infected cows [7, 37], others confirm the results obtained in this study and found a decrease of fat content at the same time with increases of milk EC [38].

There were no significant differences in protein content for the first two lactation intervals (3.25±0.04% *vs.* 3.32±0.04%, *p>0.22*). The protein content significantly increased at 3.53±0.04% between 61 and 100 DIM *(p≤0.001).*

The data available in the literature often provide contradictory results regarding the dynamics of protein content, assessed according to values of milk EC and the SCC. Generally, an increase of protein content in parallel with increased EC and SCC could be observed [38, 39, 40]. Increased protein content occurs because of the assessment method used, which is based on the N^+ concentration. The nitrogen ions are high when infection of the mammary gland is high. Analysing the presence of casein confirms its reduction in milk from mastitis infected cows. However, some specialized studies provide outcomes which demonstrate a decrease of protein content in milk affected by mastitis infections [41]. In our study we found an increase of protein content in parallel with a reduction of the milk EC, these results being different from those of Litwinczuk *et al*. which founded a linear dynamics of milk protein [42]. The ascendant trend of protein content recorded for this study showed an increase of 8.61% for the first 100 DIM. The calculated correlation coefficient between protein content and the EC values was low for the three periods of the lactation included in present study (R=0.16, R=0.07, and R=0.08, respectively).

Multifactor regression model applied (Table 5) showed a strong influence of DIM and parity in all models applied. The milk EC had a non-significant influence on this parameter, possibly because in this study, the value of milk EC does not reflect a disease of mammary gland.

Table 5. Multifactorial regression model for protein content according to the influence factors association model

Parameter	EC	Month of calving	DIM	Parity
Protein content (%)	*p>0.25*	*p>0.22*	*p≤0.001*	*p>0.001*
	p>0.5		*p≤0.001*	*p>0.001*
	p>0.23		*p≤0.001*	
		p>0.43	*p≤0.001*	*p≤0.001*
			p≤0.001	*p≤0.001*

Significantly at *p≤0.05*

There were no significant differences regarding lactose content in lactation intervals sequences. For the first 30 DIM a lactose content of 4.82±0.03% was recorded compared to 4.87±0.03% for the 31-60 DIM *(p>0.36)*, and 4.92±0.04% for the 61-100 DIM *(p>0.08)*. The dynamics of the milk lactose content was strongly and negatively correlated with the milk EC (R=-0.64) [38]. High levels of milk EC lead to an increase of milk pH and hence to an increasing of milk acidity, which reduces the lactose content [20, 44, 45]. Despite the strong correlation with milk EC, the lactose secretion is not affected by it. Lesions of the mammary epithelium makes that lactose to be expelled, this being found in blood and urine of cows affected by mastitis, specific analyses in this respect being helpful for accurate diagnosis of mastitis [37, 46]. The fact that in our study there were not found significant variations for lactose content in lactation intervals sequences according to milk EC raises a serious question about accuracy in prediction of mammary disorders based on the milk EC assessment. The calculated correlation coefficients between lactose content and milk EC were negative moderate to small values, showing a decreasing trend along the lactation interval sequences (R=-0.24, R=-0.12, and R=-0.03, respectively). Multifactor regression model applied (Table 6) showed a strong influence of DIM and parity in all models applied. The milk EC had a non-significant influence on lactose content. It is possible that in our study, the value of milk EC do not reflect a disease of mammary gland.

Table 6. Multifactorial regression model for lactose content according to the influence factors association model

Parameter	EC	Month of calving	DIM	Parity
Lactose content (%)	*p>0.17*	*p≤0.001*	*p≤0.028*	*p>0.71*
	p>0.16	*p≤0.001*	*p≤0.028*	
	p>0.3	*p≤0.001*		*p>0.69*
	p≤0.032		*p>0.14*	*p>0.43*
	p>0.28	*p≤0.001*		

Significantly at *p≤0.05*

The lactose content is subjected to a powerful influence from the month of calving and DIM. Milk EC has not been proved to have a potentially influence in models that included month of calving. The results obtained from applying multifactor regression model confirm that in this study milk EC does not influence the content of lactose. Implicitly, a question mark about accuracy of the results obtained by using only the milk EC in assessing the degree of udder health is raised.

The highest value for milk EC was recorded during the first 30 DIM (9.7±0.12 mS/cm). In DIM sequences, the milk EC decreased significantly to 9.04±0.12 mS/cm for second DIM period *(p≤0.001)* and to 8.17±0.11 mS/cm *(p≤0.001)* for the third period.

Studies conducted on this topic obtained encouraging results, although often diametrically opposed, accepted by the scientific community, whereby an increase of milk EC denotes (largely) an imminent mastitis, even with 7-14 days before its clinical diagnosis. Basically, milk EC is a parameter strongly correlated with SCC being increasingly used in the early detection of mastitis. Different installation mechanisms of mastitis, individualized forms of cow's reaction and different intensities of changes in EC and SCC leads to conflicting and uneven results concerning the degree of correlation between EC and SCC. Norberg *et al.* has calculated significant correlation coefficients between EC and SCC (R=0.65-0.8) [25, 26, 27]. These results are not generalized, Nielen *et al.* (1992) and Kamphuis *et al.* (2008) finding low correlations [47, 48]. In the present study low correlation between milk EC and SCC was calculated (R=0.14). The conducted analyses proved that milk EC not necessarily involved a high level of SCC. In this is possibly that milk EC could be induced by other factors, at least in this case.

The multifactorial regression model applied (Table 7) highlighted the significant effects exerted by the month of calving and implicitly by the ambient temperature on milk EC in different models applied.

Table 7. Multifactorial regression model for milk electrical conductivity according to the influence factors association model

Parameter	Month of calving	DIM	Parity
EC (mS/cm)	*p≤0.001*	*p≤0.034*	*p>0.36*
	p≤0.001		*p>0.36*

Significantly at *p≤0.05*

Milk EC varied according to the month of calving and was related to the ambient temperature. Thus, milk EC during the first 30 DIM (mainly August) was higher, and then the values decreased together with the reducing ambient temperatures. The results confirm previous studies carried out by Yarabbi *et al*. (2014) [49]. A significant increase in milk EC while increasing SCC was observed (Table 3). However, there was no significant difference for milk production and its chemical composition between clinically healthy cows (SCC≤200x10^3) and those with a high SCC (between 200 and 400x10^3). At a higher SCC (>400x10^3), related to an EC of 12 mS/cm, a significant reduction of milk production and chemical components occurred.

The results obtained in this study lead us to conclude that using only the milk EC to predict the mastitis presence can lead to erroneous results, situation claimed by Taylor (2004) and Hamman (2005) [50, 51], as well.

4. Conclusions

High values of milk EC right after calving lead to a decrease of milk production for the entire study period. Fat and protein content increase in lactation intervals sequence in parallel with EC decrease. Milk fat content is strongly influenced by the month of calving and DIM. Milk protein content is strongly influenced by DIM. Lactose content does not record significant variations, being influenced by month of calving and DIM. Milk EC decreases in lactation intervals sequence. Higher values are recorded during the first 30 DIM. Milk EC was highly influenced by the month of calving and DIM. Electrical conductivity of milk increases in parallel with SCC. However, both milk production and its chemical composition does not show the same trend as electrical conductivity, which requires an accurate diagnosis of mastitis based on other methods. Parity had an influence on milk EC, higher EC values being observed in primiparous cows. In association with other factors included in the present study, parity has not proved to have an effect on milk EC, while month of calving and DIM had a strong effect.

The results of this study recommend diagnosing mastitis based on complementary analyses besides milk EC, which could be used only as an auxiliary method.

Acknowledgements

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-1402.

References

1. Bareille, N., Beaudeau, F., Billon, S., Robert, A., Faverdin, P., Effects of health disorders on feed intake and milk production in dairy cows, Lives. Prod. Sci., 2003, 83(1), pp. 53–62.

2. Seegers, H., Fourichon, C., Beaudeau, F., Production effects related to mastitis and mastitis economics in dairy cattle herds, Vet. Res., 2003, 34(5), pp. 475-481.

3. Wilson, D.J., Gonzále,z R.N., Hertl, J., Schulte, H.F., Bennett, G.J., Schukken, Y.H., Gröhn ,Y.T., Effect of Clinical Mastitis on the Lactation Curve: A Mixed Model Estimation Using Daily Milk Weights, J. Dairy Sci., 2004, 87(7), pp. 2073-2084.

4. Milner, P., Page, K., Hillerton L., The Effects of Early Antibiotic Treatment Following Diagnosis of Mastitis Detected by a Change in the Electrical Conductivity of Milk, J. Dairy Sci., 1997, 80(5), pp. 859–863.

5. Janzekovic, M., Brus, M., Mursec, B., Vinis, P., Stajnko, D., Cus, F., Mastitis detection based on electric conductivity of milk, Journal of Achievements in Materials and Manufacturing Engineering, 2009, 34(1), pp. 39-47.

6. Lukas, J.M., Reneau, J.K., Wallace, R., Hawkins, D., Munoz, Z., A novel method of analyzing daily milk production and electrical conductivity to predict disease onset, J. Dairy Sci., 2009, 92(12), pp. 5964-5976.

7. Pyörälä, S., Indicators of inflammation in the diagnosis of mastitis, Vet. Res. 2003, 34(5), pp. 565-578.

8. Sloth, K.H.M.N., Friggens, N.C., Løvendahl, P., Andersen, P.H., Jensen, J., Ingvartsen, K.L., Potential for Improving Description of Bovine Udder Health Status by Combined Analysis of Milk Parameters, J. of Dairy Sci., 2003, 86(4), pp., 1221–1232.

9. Vytautas, Š., Irena, K., Algimantas, M., A comparison of indirect methods for diagnosis of subclinical mastitis in lactating dairy cows, Veterinarski Arhiv, 2006, 76(2), pp. 101-109.

10. Güven, K, Ömer, C, Enver, B.B, Mehmet, C.G., Relations between electrical conductivity, somatic cell count, California mastitis test and some quality parameters in the diagnosis of subclinical mastitis in dairy cows, Turk J Vet Anim Sci, 2012, 36(1), pp. 49-55.

11. de Mol, M., Ouweltjes, W., Kroeze, G. H., Hendriks, M. M. W. B., Detection of Estrus and Mastitis: Field Performance of a Model, Applied Engineering in Agriculture, 2001, 17(3), pp., 399–407.

12. Norberg, E., Rogers, G.W., Goodling, R.C., Cooper, J.B., Madsen, P., Genetic Parameters for Test-Day Electrical Conductivity of Milk for First-Lactation Cows from Random Regression Models, J. of Dairy Sci., 2004, 87(6), pp., 1917-1924.

13. Ilie, L.I., Tudor, L., Anca, Maria Galiş, The Electrical Conductivity of Cattle Milk and The Possibility of Mastitis Diagnosis in Romania, Lucrări Științifice Medicină Veterinară, 2010, XLIII(2), pp. 220-227.

14. Hammer, J.F., Morton, J.M., Kerrisk, K.L., Quarter-milking-, quarter-, udder- and lactation-level risk factors and indicators for clinical mastitis during

lactation in pasture-fed dairy cows managed in an automatic milking system, Aust. Vet. J., 2012, 90(5), pp., 167-174.
15. Tančin, V., Ipema, B., Hogewerf, P., Mačuhová, J., Sources of Variation in Milk Flow Characteristics at Udder and Quarter Levels, J. of Dairy Sci., 2006, 89(3), pp., 978-988.
16. Alberto, T., Luciana, B., Renata, P., Alfonso, Z., Magdalena, Z., Anna, S., Milk emission and udder health status in primiparous dairy cows during lactation, J. of Dairy Res., 2010, 77(1), pp., 13-19.
17. Sandrucci, A., Tamburini, A., Bava, L., Zucali, M., Factors Affecting Milk Flow Traits in Dairy Cows: Results of a Field Study, J. of Dairy Sci., 2007, 90(3), pp., 1159-1167.
18. Murray,W. Woolford, John, H. Williamson, Harold, V. Henderson, Changes in electrical conductivity and somatic cell count between milk fractions from quarters subclinically infected with particular mastitis pathogens, J. of Dairy Res., 1998, 65(2), pp., 187-198.
19. Tančin, V., Ipema, A.H., Hogewerf, P., Interaction of Somatic Cell Count and Quarter Milk Flow Patterns, J. of Dairy Sci., 2007, 90(5), pp. 2223-2228.
20. Baljinder, K. Bansal, Joern, H., Nils, T. G., Krishan, B. S., Variation in the composition of selected milk fraction samples from healthy and mastitic quarters, and its significance for mastitis diagnosis, J. of Dairy Res., 2005, 72(2), pp., 144-152.
21. Johan, S., Plasmin activity and proteose-peptone content of individual milks, J. of Dairy Res., 1985, 52(3), pp., 369-378.
22. William, J.D., Gerard, J.B., Casein compositional studies. III. Changes in Irish milk for manufacturing and role of milk proteinase, J. of Dairy Res., 1983, 50(4), pp., 433-441.
23. Mara, L., Germano, M., Erasmo, N., Analysis of Conductance Changes as a Growth Index of Lactic Acid Bacteria in Milk, J. of Dairy Sci., 1993, 76(1), pp., 20-28.
24. Kaptan, S. B., Kayışoğlu, M. Demirci, The Relationship Between Some Physico-Chemical, Microbiological Characteristics and Electrical Conductivity of Milk Stored at Different Temperature, J. of Tekirdag Agri. Fac., 2011, 8(2), pp., 13-21.
25. Norberg, E., Hogeveen, H., Korsgaard, I.R., Friggens, N.C., Sloth, K.H.M.N., Løvendahl, P., Electrical Conductivity of Milk: Ability to Predict Mastitis Status, J. of Dairy Sci., 2004, 87(4), pp., 1099-1107.
26. Norberg, E., Electrical conductivity of milk as a phenotypic and genetic indicator of bovine mastitis: A review, Lives. Prod. Sci., 2005, 96(2-3), pp., 129-139.
27. Norberg, E., Rogers, G.W., Ødegård, J., Cooper, J.B., Madsen, P., Short Communication: Genetic Correlation Betwen Test-Day Electrical Conductivity of Milk and Mastitis, J. of Dairy Sci., 2006, 89(2), pp., 779-781.
28. Hill, T., Lewicki, P., Statistics: Methods and Applications. StatSoft, 2012, Tulsa, OK, USA.
29. Kocak O., Influence of Mastitis on Milk Yield in Holstein, Acta Vet. Brno, 2006, 75(4), pp., 507-513.
30. Rajala, P.J., Grohn, Y.T., McCulloch, C.E., Guard, C.L., Effects of Clinical Mastitis on Milk Yield in Dairy Cows, J. of Dairy Sci., 1999, 82(6), pp., 1213-1220.
31. Hagnestam-Nielsen, C., Emanuelson, U., Berglund, B., Strandberg, E., Relationship between somatic cell count and milk yield in different stages of lactation, J. of Dairy Sci., 2009, 92(7), pp., 3124-3133.
32. Ontsouka, C.E., Bruckmaier, R.M., Blum, J.W., Fractionized Milk Composition During Removal of Colostrum and Mature Milk, J. of Dairy Sci., 2003, 86(6), pp., 2005-2011.
33. Kleen, J. L., Hooijer, G. A., Rehage, J., Noordhuizen, J. P. T. M., Subacute Ruminal Acidosis (SARA): a Review, Journal of Veterinary Medicine, 2003, 50(8), pp., 406–414.
34. Kenneth, V.N., Nigel, B.C.,Using herd records, Vet. Clin. North Am., 2004, 20:627-649.
35. Nishimori, K., Okada, K., Ihuta, K., Aoki, O., Sakai, T., Yasuda, J., The effects of one time hoof trimming on blood biochemical composition, milk yield and milk composition in dairy cows, J. Vet. Med. Sci., 2006, 68:267-270.
36. Masoud, N.N., Seyed, A.M., Arash, K., Jegfar, K., Boulbaba, R., Fat and Protein Contents, Acidity and Somatic Cell Counts in Bulk Milk of Holstein Cows in the Khorasan Razavi Province, Iran, Int. J. of Dairy Technology, 2009, 62(1), pp., 19-26.
37. Bruckmaier, B.M., Ontsouka, C.E., Blum, J.W., Fractionized milk composition in dairy cows with subclinical mastitis, Vet. Med. Czech, 2004, 49(8), pp., 283-290.
38. Auldist, M.J., Hublle, I.B. Effects of Mastitis on Raw Milk and Dairy Products, Australian J. of Dairy Sci., (1998), 53(1), pp., 28-36.
39. Shuster D.E., Harmon, R.J., Jackson, J.A., Hemken, R.W., Suppression of Milk Production During Endotoxin-Induced Mastitis, J. of Dairy Sci., 1991, 74(11), pp., 3763-3774.
40. Mohammed, M., Petty, M.C., Effect of Composition on the Electrical Conductance of Milk, J. of Food Engineering, 2003, 60(3), pp., 321-325.
41. Amanda, S., The 'Udder' Side of Precision Dairy Monitoring, 2013, http//www.extension.psu.edu
42. Litwińczuk, Z., Król, J., Brodziak, A., Barłowska, J., Changes of protein content and its fractions in bovine milk from different breeds subject to somatic cell count, J. of Dairy Sci., 2011, 94(2), pp., 684-691.
43. Ostan, M, Gogoașă, I., Rada, O.A., Bau,l B., Fericean, M., Cazacu, M., Petcu, M., Crețescu, I., The Effect of Boiling on the pH, EC and Lactose Content of Cow Milk, Research J. of Agricultural Sci. 2015, 47(2), pp., 130-132.

44. Caroline, Le Maréchal, Richard, T., Eric V., Yves, Le Loir, Mastitis impact on technological properties of milk and quality of milk products—a review, Dairy Sci. and Tech., 2011, 91(3), pp., 247-282.
45. Carolina, B. M., Juliana, R. B., Lucinéia, M., Marco A., Marcos V., Effect of somatic cell count and mastitis pathogens on milk composition in Gyr cows, BMC Veterinary Research, 2013, 9(1), pp., 67-74.
46. Nguyen, Dad; Neville, M.C., Right Junction Regulation in the Mammary-Gland, Journal of Mammary Gland Biology and Neoplasia, 1998, 3(3), pp. 233-246.
47. Nielen, M., Deluyker, H., Schukken, Y.H., Brand, A., Electrical Conductivity of Milk: Measurement, Modifiers, and Meta-Analysis of Mastitis Detection Performance, J. of Dairy Sci., 1992, 75(2), pp., 606-614.
48. Kamphuis, C., Sherlock, R., Jago, J., Mein, G., Hogeveen, H.,Automatic Detection of Clinical Mastitis Is Improved by In-Line Monitoring of Somatic Cell Count, J. of Dairy Sci., 2008, 91(12), pp., 4560-4570.
49. Yarabbi, H., Mortazavi, A., Mehraban, M., Sepehri, N., Effect of Somatic Cells on the Physic-Chemical and Microbioal Properties Of Raw Milk in Different Seasons, International Journal of Plant, Animal and Environmental Sciences, 2014, 4(3), pp., 289-298.
50. Vanessa, T., The Warning Signs of Mastitis - Analyzing a Combination of Factors to Decide When to Treat Dairy Cows, 2012, http//www.omafra.gon.on.ca
51. Hamann, J., Zecconi, A., Evaluation of the electrical conductivity of milk as a mastitis indicator, 1998, http//www.agris.fao.org