Vol. 14(27), pp. 1163-1168, 4 July, 2019
DOI: 10.5897/AJAR2019.14113
Article Number: D2B34A961324
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Thermal comfort estimation for dairy cows in the south of Goiás State, Brazil

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Received 16 April, 2019; Accepted 21 June, 2019

The objective of this research was to analyze the correlation between climatic and milk composition variables. Thus, meteorological data and data on milk quality and composition (fat, protein, lactose, total solids content and defatted dry extract (DDE)) were used, as well as somatic cell count (SCC). The analysis was performed using the Pearson correlation test. After the study, it was verified that the temperature variations had a significant correlation with the fat, protein and total solids contents, as well as the temperature-humidity index (THI) also had correlation with lactose. In the analysis between the components, the correlations were between fat and protein, fat and total solids content, protein and total solids content, and lactose and fat. Moreover, SCC correlation with DDE and lactose were considered. The thermal comfort of dairy females has a direct influence on the quantity and quality of the final dairy product.

Key words: Dairy cattle, milk production, welfare.

INTRODUCTION

The dairy cattle are more sensitive and lacking more specific care to maintain good productivity due to the climatic variations that occur in the tropical climate. Thus, according to Rossarolla (2007), the management of dairy cattle to pasture leads the animals more vulnerable to higher temperatures, as in the case of countries with a warm climate. With the need to offer artificial shadows to the animals, aiming at improving thermal comfort and reducing losses in milk production by stress. High temperatures, prolonged days length and few shadows to the animals, decreases dairy cow productivity (Fagan et al., 2010).

Mastitis is an inflammation of the mammary gland. The inflammatory response are to destroy or neutralize the injurious agent and allow healing and return to normal function. The inflammation is the influx of white blood cells or leukocytes which results in an increase in the somatic cell count (SCC) of milk; although, the SCC is a usual measure of mammary gland health and milk quality (Harmon, 1995).

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The quantitative distribution of milk components informs about their quality (Noro et al., 2006). The consumer market raises its requirement for products with superior quality. Dangers of degradation of milk with eradication of contamination by undesirable bacteria and also by unusual solids should be reduced (Vallin et al., 2009).

When the animal stress increases, its welfare decreases, and hence, it is possible to conclude that the production efficiency of the cows is linked to the quality of the dairy cow environment (Rossarolla, 2007). One of the ways to evaluate the thermal comfort of milk cows is by temperature-humidity index (THI) to indicate the level of thermal comfort, to evaluate the welfare of several animals, as in this study for dairy cattle (Perissinotto and Moura, 2007).

Therefore, the objective of this study was to evaluate the determinant effect of climatic indexes on milk production in dairy farms located in the city of Morrinhos, southern region of the state of Goiás.

MATERIALS AND METHODS

Data on milk production and quality were obtained from the Company Mixed Cooperative Milk Producers of Morrinhos (COMPLEM), through a logistic information control system. Information from 94 dairy farms in the city of Morrinhos, state of Goiás, Brazil, was used for the period from March 2015 to August 2018, reaching a total of 3,948 observations. The climatic and meteorological data used in the development of the study were collected from the Meteorological Station installed at the Institute Federal Goiano - Campus Morrinhos (located at the geographic coordinates: Latitude 17º 48' 50.4" S; longitude 49º 12' 16.5" W; altitude 902 m).

In this study, total milk production, milk quality, fat, protein, lactose, defatted dry extract (DDE), total solids content and somatic cell count (SCC) were analyzed, after collected data.

Regarding the climatological factors, data of average temperature, maximum and minimum, relative humidity and temperature-humidity index (THI) were analyzed. In order to determine the THI, the following model was used: THI = T = 0.55 (1-UR) (T-58), where T = ambient temperature in °F and UR = relative humidity in decimal number (Roma Júnior et al., 2009).

The information collected was arranged in a single spreadsheet, organized in order of properties and the respective months of the year, in order to analyze the correlations between milk production, milk composition and climatic measures by means of statistical analysis. The equation for Pearson's correlation is described below in Equation 1.

$$\rho = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-x)^2\sum(y-y)^2}} \quad (1)$$

Pearson's correlation using the statistical program SAS, (2001) (SAS® University Edition).

RESULTS AND DISCUSSION

Milk composition

For milk production, there was no significant correlation with any environmental variables or milk composition. However, according to Bertoncelli et al. (2013), milk production is clearly associated with the duration of thermal comfort in which the dairy cow is exposed, that is, the lower the thermal stress, the greater its milk production.

For the evaluated components, protein had the highest correlation with the maximum and minimum temperature indices, with r = -0.18027 and r = -0.17489, respectively, as shown in Table 1. Nakamura et al. (2012), for protein analysis, had similar results, it was also negative correlation, r = - 0.250, for maximum temperature and r = -0.218, for minimum temperature. When the cow is subjected to high temperature stress, a change in its feed intake and digestion occurs. It results in alteration of the microorganism population with variation in the percentage of volatile fatty acids in the rumen produced results in a reduction in the amount of propionic acid, with a decrease in milk protein levels (Van Soest, 1994). In conditions of thermal discomfort, the animal naturally exhibits physiological and behavioral changes, and consequently, its productivity decrease. Thus, dairy cows have a reduction in feed intake and grazing, with grazing preference at night, as well as search for water and shade sites, increased water consumption and respiratory rate (Rossarolla, 2007).

For protein, the study also showed a negative correlation with the mean temperature (r = -0.17694). According to Vargas et al. (2014), there is a positive correlation for mean temperature with somatic cell count at a value of r = 0.34, this correlation is considered as mean.

These results with the heat-stressed animals tend to increase the SCC, had as a consequence, the reduction of the protein content of the milk produced. According to Pereira et al. (1999), the modification in the proportion of protein and in other constituents of milk is by the decrease in the efficiency of synthesizing the secretor cells. Fat, however, is the most inconstant constituent that is incorporated in milk; depends on factors such as genetics, feed management and environment (Fagan et al., 2010). The Jersey breed has its genetic selection to produce milk with the highest percentage of fat (Botaro et al., 2011). According to Reis et al. (2012), the Holstein breed is more productive, and their milk contained lower concentration of lipids and proteins when compared to the Girolando breed and cows crossbreed. The fat content values were also negative and significant, however, the correlation results for this variable are classified as low, -0.12228 for fat correlation with maximum temperature and –0.12454 for correlation with minimum temperature. Nakamura et al. (2012), with negative correlation values with mean intensity (r = -0.586 and r = - 0.619), in this order. Thus, Noro et al. (2006), pointed out the proportion of fat is higher during the winter season, when compared to the summer days, due to the change in feed intake of roughage tropical and

Table 1. Pearson's linear correlation between maximum and minimum temperatures and milk components**.**

Component of milk	Temperature maximum (°C)	Temperature minimum (°C)	P value
Fat (r)	- 0.12228	- 0.12454	0.0001
Protein (r)	- 0.18027	- 0.17489	0.0001
Total solids content (r)	- 0.13160	- 0.13113	0.0001

r: Correlation value; correlations were significant ($p < 0.05$).

Table 2. Pearson's linear correlation between temperature-humidity index (THI) and milk components.

Component of milk	Temperature-humidity index (THI)	P value
Protein (r)	- 0.10513	0.0001
Fat (r)	- 0.13471	0.0001
Lactose (r)	0.15004	0.0001
Total solids content (r)	- 0.11576	0.0001

r: Correlation value; correlations were significant ($p < 0.05$).

temperate by dairy cows. Dairy cows exposed to heat stress have reduced ruminal contractions, and for this reason, they are more predisposed to acidosis. This reduction in contractions reflects unfavorably on the production of saliva, causing a reduction in the pH of the rumen. This type of alteration can also be associated with a decrease in the proportion of volatile fat acids (VFAs), within the rumen in stress condition (Valente et al., 2017). Mota et al. (2010) observed that cows with a lower proportion of acetate in rumen affected fat production in milk.

Nakamura et al. (2012), in their study revealed a negative correlation between the maximum temperature and the fat level. The correlation values for total solids and for fat were negative and low, with both maximum and minimum temperature, expressing r = -0.13160 and r = -0.13113, respectively. The proportion of total solids is reduced in the summer when compared to other seasonal seasons, and is based on the decrease in the dry matter intake that occurs due to the climate with high temperatures. The result is the correlation between total solids and temperature indices (Fagan et al., 2010).

Relationship between environmental effects and somatic cell counts

The somatic cell count represents the presence of defense cells in the mammary gland. Thus, SCC of dairy cattle indicates the level of udder inflammation (Machado et al., 2000). Directly related to the appearance of mastitis, the percentage of somatic cells is used as a primordial instrument in the determination of subclinical mastitis (Araújo et al., 2012) when there is an increase in air humidity, which may contribute to higher rates of SCC and diseases of the mammary gland (Nakamura et al., 2012). Thus, dairy cows exposed to high temperatures exhibit reduced ability to protect against invasions of deleterious microorganisms (Porcionato et al., 2009). This is because it is possible to associate climatic variables with the somatic cell count.

Temperature-humidity index (THI)

The variables that affect the dispersion of body heating are air humidity and temperature. In order to better understand the influence of environmental variables on the welfare of dairy cows in lactation, THI was established, an instrument to measure the thermal disturbance, which associates the effects of the two measures mentioned above. The higher the value, the greater the animal discomfort. The THI is considered high, when it exceeds 68 points (Prado, 2018).

For the protein level, it had a negative correlation, but low intensity with THI, as shown in Table 2, against the result by Silva and Antunes (2018), which had no correlation between these two variables. However, this decrease in protein levels due to thermal stress is also associated with decreased feed intake, which will lead to a decrease in the production of microbial protein (Valente et al., 2016).

Regarding milk fat, there was a negative correlation with THI, as identified by Silva and Antunes (2018), which may be justified because, under warm conditions, there is a spontaneous decline in pasture and silage intake, leading to a reduction in fat levels in milk. Animals submitted to high THI values are 85% more likely to decrease grass grazing (Rodrigues et al., 2010; Prado, 2018).

Only for lactose had positive correlation, and in agreement with Silva and Antunes (2018), in a similar study also had a positive correlation between lactose and THI. Therefore, as the THI increases, the higher the

Table 3. Pearson's linear correlation between milk components.

Components of milk	Correlation value	P value
Fat x protein	0.23576	0.0001
Fat x total solids content	0.91426	0.0001
Protein x total solids content	0.52707	0.0001
Lactose x fat	- 0.25930	0.0001

Correlations were significant (p <0.05).

Table 4. Linear Pearson correlation between milk components and somatic cell count**.**

Components of milk	Correlation value	P value
DDE x SCC	- 0.30148	0.0001
Lactose x SCC	- 0.45169	0.0001

Correlations were significant (p <0.05).

percentage of lactose. The environmental factors reflect unfavorably on lactose and fat, noting that the elevation of the climate variables and the welfare indicators, causes the reduction of lactose and fat levels in milk.

The correlation between total solids and THI was negative and low, similar results found with Silva and Antunes (2018), obtained a negative correlation for these variables. The levels of total dry extract are higher in the winter season, and decrease in summer (Henrichs et al., 2014) confirm that the influence of temperature and humidity on these results for these compounds. A positive correlation between fat and milk protein (r = 0.23576, considered weak) in Table 3 contrary to Henrichs et al. (2014), which had a negative correlation between these variables.

The correlation between fat and milk protein was similar between the seasons and months of the year, where fat and protein appear as great indicators of milk quality, the most favorable results of measurement of these two items were obtained in the period of the lowest rainfall index and with minimum temperatures, confirming the direct influence of the environment and animal welfare on the proportion of these components in the milk (Roma Júnior et al., 2009). The reduced percentage of milk fat is a consequence of the dilution effect due to increased milk production (Fagan et al., 2010; Prado, 2018).

Already, the correlation between fat and total solids content was high, almost reaching 1, as was exposed by Henrichs et al. (2014). Zanela et al. (2006) confirms that total solids content levels increase as the fat percentage increases. This relation is related to the producing breed, for the milk produced by Jersey cows, greater percentage of fat and, consequently, greater proportion of total solids content.

The protein content is considerably relevant to determine the milk yields in the dairy industry (Henrichs et al., 2014). Casein appears to be the most important protein in dairy products. In this study, there was a positive correlation between total solids and milk protein in Table 4, a result similar to Henrichs et al. (2014). Reis et al. (2012) presented a value of r = 0.58, very similar to the value in this study. Protein and total solids have similar results when compared to the seasons, with the highest percentage in autumn and winter, decreasing during the spring and summer periods in the tropical climate (Henrichs et al., 2014). The correlation between lactose and fat in the milk was negative among the components (r = - 0, 25930). As for lactose, it is the sugar present in milk, and it is also the constituent with lower rate of change, unlike fat, which has a greater instability characteristic (Van Soest, 1994). This confirms the negative correlation result observed in the present study.

Mastitis lead to changes in the constitution of milk produced by the dairy cow (Pereira et al.,1999). The highest somatic cell count measurements occur in summer (Bueno et al., 2005). For the DDE analysis, it had a negative correlation with the SCC, with a considered average value. Montanhini et al. (2013), in their study had found a negative correlation value equal to -0.227. On the other hand, the result of Rangel et al. (2009), in his analysis was a positive correlation between SCC and DDE, for a situation of mechanically milked cows of the Holstein breed, and DDE, which does not involve the fat content of milk. The increase in SCC leads to increased fat levels (Lacerda et al., 2010; Montanhini et al., 2013). This is due to the fact that inflammation in the udder caused a decrease in the total volume of milk produced by the cow and accumulation of fat (Machado et al., 2000).

The correlation between lactose and SCC, as well as total solids, was negative for both considered of medium degree. In agreement with what was exposed by Bueno et al. (2005), which also had a negative correlation between SCC and lactose, and it is possible to conclude that lactose is the constituent with the highest decrease, and the SCC increases. Reis et al. (2012) also had found negative mean correlation for lactose and somatic cell counts. Botaro et al. (2011) stated that cows with mastitis have a decrease in lactose levels, as a result of the fall in the synthesis of this constituent under these animal health conditions.

Conclusion

Thermal comfort directly influences the quality and quantity of milk produced by dairy cows under conditions of thermal stress, milk production decreased, milk composition changed. Indirectly, the thermal comfort exerts influence in the health and the capacity of defense of these animals against pathogens.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The research is financed by IFGoiano, Go, Brazil.

REFERENCES

Araújo VM, Rangel AHN, Bezerra KC, Andrade KD, Guerra MG (2012). Avaliação de testes rápidos para análises da contagem de células somáticas de leite cru de tanques. Acta Veterinaria Brasilica 6(4):321-324.

Bertoncelli P, Martin TN, Ziech MF, Paris W, Cella PS (2013). Conforto térmico alterando a produção leiteira. Revista Enciclopédia Biosfera 9(17):762-777.

Botaro BG, Cortinhas CS, Mestieri L, Machado PF, Santos MV (2011). Composição e frações proteicas do leite de rebanhos bovinos comerciais. Vet. e Zootec 18(1): 81-91.

Bueno VFF, Mesquita AJ, Nicolau ES, Oliveira NA, Oliveira JP, Neves RBS, Mansur JRG, Thomaz LW (2005). Contagem celular somática: relação com a composição centesimal do leite e período do ano no Estado de Goiás. Ciência Rural 35(4):848-854.

Fagan EP, Jobim CC, Calixto Júnior M, Silva MS, Santos GT (2010). Fatores ambientais e de manejo sobre a composição química do leite em granjas leiteiras do Estado do Paraná, Brasil. Acta Scientiarum. Animal Sciences 32(3):309-316.

Harmon R (1995). Mastitis and milk quality. In: Harding F. (eds) Milk Quality. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-2195-2_3

Henrichs SC, Macedo REF, Karam LB (2014). Influência de indicadores de qualidade sobre a composição química do leite e influência das estações do ano sobre esses parâmetros. Revista Acadêmica: Ciência Animal 12(3):199-208.

Lacerda LM, Mota RA, Sena MJ (2010). Contagem de células somáticas, composição e contagem bacteriana total do leite de propriedades leiteiras nos municípios de Miranda do Norte, Itapecurú– Mirim e Santa Rita, Maranhão. Arquivos do Instituto Biológico 77(2):209-215.

Machado PF, Pereira AR, Sarríes GA (2000). Composição do leite de tanques de rebanhos brasileiros distribuídos segundo sua contagem de células somáticas. Revista Brasileira de Zootecnia 29(6):1883-1886.

Montanhini MTM, Moraes DHM, Neto RM (2013). Influência da contagem de células somáticas sobre os componentes do leite. Revista do Instituto de Laticínios Cândido Tostes 68(392):18-22.

Mota MF, Vilela D, Santos GT, Elyas ACW, Lopes FCF, Verneque RS, Paiva PCA, Pinto Neto A (2010). Parâmetros ruminais de vacas leiteiras mantidas em pastagem tropical. Archivos de Zootecnia 59(226):217-224.

Nakamura AY, Alberton LR, Otutumi LK, Donadel D, Turci RC, Agostinis RO, Caetano ICS (2012). Correlação entre as variáveis climáticas e a qualidade do leite de amostras obtidas em três regiões do estado do Paraná. Arquivos de Ciências Veterinárias e Zoologia da UNIPAR 15(2):103-108.

Noro G, González FHD, Campos R, Dürr JW (2006). Fatores ambientais que afetam a produção e a composição do leite em rebanhos assistidos por cooperativas no Rio Grande do Sul. Revista Brasileira de Zootecnia 35(3):1129-1135.

Pereira AR, Silva LFP, Molon LK, Machado PF, Barancelli G (1999). Efeito do nível de células somáticas sobre os constituintes do leite I-gordura e proteína. Brazilian Journal of Veterinary Research and Animal Science 36(3):121-124.

Perissinotto M, Moura DJ (2007). Determinação do conforto térmico de vacas leiteiras utilizando a mineração de dados. Revista Brasileira de Engenharia de Biossistemas 1(2):117-126.

Prado DMB (2018). Temperatura corporal e comportamento de vacas leiteiras em pastejo. Trabalho de Conclusão de Curso (Graduação em Medicina Veterinária). Uberlândia, 29p.

Porcionato MAF, Fernandes AM, Netto AS, Santos MV (2009). Influência do estresse calórico na produção e qualidade do leite. Revista Acadêmica: Ciência Animal 7(4):483-490.

Rangel AHN, Medeiros HR, Silva JBA, Barreto MLJ, Dorgival Júnior ML. (2009). Correlação entre a contagem de células somáticas (SCC) e o teor de gordura, proteína, lactose e extrato seco desengordurado do leite. Revista Verde de Agroecologia e Desenvolvimento Sustentável 4(3):57-60.

Reis AM, Costa MR, Costa RG, Suguimoto HH, Souza CHB, Aragon-Alegro LC, Ludovico A, Santana EHW (2012). Efeito do grupo racial e do número de lactações sobre a produtividade e a composição do leite bovino. Semina 33(2):3421-3436.

Rodrigues AL, Souza BB, Pereira Filho JM (2010). Influência do sombreamento e dos sistemas de resfriamento no conforto térmico de vacas leiteiras. Agropecuária Científica no Semiárido 6(2):14-22.

Roma Júnior LC, Montoya JFG, Martins TT, Cassoli LD, Machado PF (2009). Sazonalidade do teor de proteína e outros componentes do leite e sua relação com programa de pagamento por qualidade. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 61(6):1411-1418

Rossarolla G (2007). Comportamento de vacas leiteiras da raça holandesa, em pastagem de milheto com e sem sombra. Dissertação (Mestrado em Zootecnia) – Centro de Ciências Rurais – Universidade Federal de Santa Maria, Santa Maria, 2007.

SAS (Statistical Analysis System) (2001). User's guide: Statistics. Cary: SAS Institute.

Silva JC, Antunes RC (2018). Efeito do tipo de ordenha e do ambiente sobre a qualidade do leite cru com base na contagem de células somáticas. Ciência Animal Brasileira 9(1-16)e-34635.

Valente TNP, Lima ES, Santos WBR, Cesario AS, Tavares CJ, Fernandes IL, Freitas MAM (2016). Ruminal microorganism consideration and protein used in the metabolism of the ruminants: A Review. African Journal of Microbiology Research 10:456-464.

Valente TNP, Sampaio CB, Lima ES, Deminicis BB, Cezário AS, Santos WBR. (2017). Aspects of acidosis in ruminants with a focus on nutrition: A review. The Journal of Agricultural Science 9(3):90-97.

Vargas DP, Nörnberg JL, Mello RO, Sheibler RB, Breda FC, Milani MP (2014). Correlações entre contagem de células somáticas e parâmetros físico químicos e microbiológicos de qualidade do leite. Ciência Animal Brasileira 15(4):473-483.

Vallin VM, Beloti V, Battaglini APP, Tamanini R, Fagnani R, Angela HL, Silva LCC (2009). Melhoria da qualidade do leite a partir da implantação de boas práticas de higiene na ordenha em 19 municípios da região central do Paraná. Semina 30(1):181-188.

Van Soest PJ (1994). Nutritional Ecology of the Ruminant. Cornell

University Press P. 476.
Zanela MB, Fischer V, Ribeiro MER, Stumpf Junior W, Zanela C, Marques LT, Martins PRG 2006. Qualidade do leite em sistemas de produção na região Sul do Rio Grande do Sul. Pesquisa Agropecuária Brasileira 41(1):153-159.