SHORT COMMUNICATION

Influence of the year and calving season on production, composition and mozzarella cheese yield of water buffalo in the State of Rio Grande Do Norte, Brazil

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Abstract

This research was carried out to evaluate the influence of the year and calving season on the production, composition and mozzarella cheese yield index (PKM) of Murrah water buffalos. We analyzed a data set of 514 lactations collected from 2004 to 2008, recorded and archived in software of a farm located in Taipu, in the eastern region of Rio Grande do Norte State, Brazil. To assess the effects of calving season, the year was divided into a rainy season (from March to August) and a dry season (from September to February). Results showed that the year influenced daily production and PKM (P<0.05). However, no effects were observed on logarithm somatic cell count (LSCC), fat, protein and total dry extract (TDE). The season had no influence on the variables analyzed and no interaction was observed between the year and the season. The season and its interactions had no effect on water buffalo performance in relation to dairy production and PKM index of mozzarella efficiency.

Introduction

In Brazil, farmers are interested in raising buffaloes with a focus on milk production and this has increased buffalo farming in different regions of the country. Production of buffalo milk and its dairy products is widespread with greater availability on the supermarket shelves for consumers who are searching not only for its special and characteristic flavor, but also looking for food quality and safety.

The cattle census (IBGE, 2008) reported a herd of 1,146,798 head and the Brazilian water buffalo herd increased by 1.3% from 2007 to 2008. A total of 134,957 head are found in the northeast, and 64.75% are in the state of Maranhão. Furthermore, from 2007 to 2008, the buffalo herd in the northeastern region increased by 12.5% against 0.5% for the cattle herd, demonstrating the growing interest in raising buffalo for milk or meat purposes.

The economic importance of buffalo farming was studied by Bernardes (2007) who found 92.3 million liters of milk were produced by approximately 82,000 female water buffalo in a total of 2,500 herds.

The dairy buffalo has a great potential for milk production and the production of milk components (%) is higher than that of cow’s milk. It also contains a higher fat and mineral content than milk from other species. Protein, total solid and solid non-fat values from buffalo milk are lower only than sheeps’ milk (Ramos, 2002). Such characteristics give buffalo milk a higher industrial yield and also give a special flavor to the dairy products.

Water buffalo milk production and its composition are directly influenced by the season of the year, given that this affects availability and forage quality (Bastianetto et al., 2005). Teixeira et al. (2005) report that water buffalo milk yields 40-50% more dairy products than that of cows’ milk. Almost all water buffalo milk production in Brazil is converted into dairy products, primarily mozzarella cheese.

Water buffalo are seasonally polyestrous. This is due to the influence of environmental and climatic factors, such as relative air humidity, rainfall, temperature and main photoperiod (Zicarelli, 2010; Ribeiro Neto et al., 2006). However, in tropical regions near the Equator, where there are no wide variations in photoperiod, the presence or lack of reproductive seasonality is influenced more by feed management and nutritional status (Garcia, 2006; Bernardes, 2007; Dantas et al., 2008).

Despite the rapid expansion of buffalo dairy farming in Brazil and the increased interest in water buffalos as milk producers, there is still much research to be done on this species. Given that milk production is a consequence of reproduction, more research into reproduction is needed to clarify long-held paradigms about the reproductive behavior of male and female water buffaloes. Brito and Brito (2001), Ramos (2002) and Bernardes (2007) clearly state that these studies could contribute to the development of technologies that could optimize and increase the economic potential of water buffalo farming for dairy produce in Brazil.

The present study, therefore, aimed to assess the effect of season of year (dry and rainy) on the production, composition and milk yield of Murrah water buffalo for producing mozzarella cheese in Taipu county, in the Agreste region of Rio Grande do Norte State, Brazil.

Materials and methods

The experiment was conducted at Tapuio Agropecuária Ltda. in Taipu county, Rio Grande do Norte State, Brazil.

The farm and milk processing plant are located at 5° 37' 18'' south latitude and 35° 35' 48'' west longitude (Institute for Economic and Environmental Development, IDEMA, 2009). The region has a tropical climate characterized by its dry and rainy seasons with 855 mm of rainfall per year (Agricultural Research Company of Rio Grande do Norte, EMPARN, 2009). Mean temperature is 25.3°C, with a

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maximum of 32°C and minimum of 21°C; mean relative humidity is 79% (IDEMA, 2009).

We analyzed the data set collected from 2004 to 2008 of milk control of 163 milking buffaloes aged from 36±3.0 to 78±6.0 months of age, for a total of 514 complete lactations. Variables analyzed were: mean daily milk production, fat, protein, total dry extract (TDE), somatic cell count (SCC) transformed to decimal logarithm (LSCC) and mozzarella yield (PKM).

The animals were maintained on rotational grazing in paddocks of Brachiaria brizantha, Brachiaria humidicola and Panicum maximum, and supplemented with a mixture of cottonseed and soybean offered during milking. In the dry season, the milking herd was fed sugarcane corrected with 9:1 parts 1% urea/ammonium sulfate mixture. The buffaloes were mechanically milked twice a day at 05:00 h and 17:00 h. Milk samples were collected at the end of each milking, then homogenized and stored in plastic bottles of 40 mL containing 8 mg of Bronopol. Each sample was identified by the number assigned to the animal and then sent for analysis to PROGENE, a laboratory for managing the milk program of milking herds of northeastern Brazil of the Department of Animal Husbandry at the University of Pernambuco (UFRPE). Samples were analyzed for fat, protein and total dry extract content, using the infrared Bentley 2000 (Bentley Instruments Inc., Chasca, MN, USA) and the somatic cell count (SCC) was determined by electronic flow cytometer (Somacount 300® , Bentley Instruments Inc.).

Statistical analyses were made only for females with at least two calving and lactation periods of not less than 210 days. Mean daily milk production was calculated for the period between 2004 and 2008, while the data used to analyze milk quality and mozzarella yield corresponded to 2007 and 2008.

The year was divided into two periods: the rainy season from March to August and the dry season from September to February.

Analysis of variance was performed according to the following model:

\[ Y_{ijk} = m + a_i + b_j + (ab)_{ij} + e_{ijk} \]

where
\[ Y_{ijk} = \text{value observed}; \]
\[ m = \text{general mean}; \]
\[ a_i = \text{effect of the year } i; \]
\[ b_j = \text{seasonal effect } j; \]
\[ (ab)_{ij} = \text{effect of year-season interaction}; \]
\[ e_{ijk} = \text{error effect}. \]

The mozzarella yield index (PKM) was estimated using the percentage of fat (%F) and protein (%P), as well as the mean daily production by the formula

\[ \text{PKM} = \frac{\text{kg of milk} \times \{13.5 \times (% \text{protein}) + 1.23 \times (% \text{fat}) - 0.88\} / 100} \]

proposed by Bufano et al., (2006).

Statistical analyses were performed by the Statistical Analyses System (SAS, 2001) and means were compared by the Tukey test at a significance level of 5%.

Results and discussion

Results from this study showed no interaction effect for year and seasons, this result differs from those of Céron-Muñoz et al. (2002).

Figure 1 shows the monthly calving distribution during the year with mean of 64.4% calving occurring in the rainy season and 35.6% in the dry season. During the period of analysis (2004 to 2008), a greater calving concentration was seen from March to September, with the lowest in February (n=16) and a maximum in April (n=66). Calving time had no effect on the variables shown in Table 1 and similar results were obtained in southern Italy by Bufano et al. (2006). There was a trend of increase in the calving number in the dry season in the period from 2004 to 2008. Thus, the results show that the difference in calving between the rainy and dry seasons was reduced. This increase in calving number might be attributed to improved management practices, which mainly concern using concentrate in feed to better meet the animals’ nutritional requirements in the dry season.

It should also be emphasized that interfering in reproductive management to promote adaptations in the calving calendar results in birth distribution throughout the year, and so maintains uniform milk production and helps meet consumer demand for mozzarella cheese all the year round.

Similar results were obtained by Galeazzi (2008) in the state of Sao Paulo, where Murrah water buffalo had 62.7% of their calving between October and March (rainy season), and also by Rolim Filho et al. (2009) who reported no reproductive seasonality in the Amazon region, with a high calving concentration from March to August, and the maximum calving occurring in April and the minimum in December. In contrast, Ribeiro Neto et al. (2006) reported reproductive seasonality in the same breed in Rondonia state where 90% of the calving occurred from January to June. This corresponds to a mating season during the rainy months and when the days are shorter, characterizing a reproductive seasonality for the buffalo, i.e. a photoperiod effect. This corresponds to fertile mating occurring in the rainy months with lower sunlight levels, characterizing reproductive seasonality in the short day Murrah breed.

There was no significant effect of calving season on milk yield, LCCS, fat, protein, TDE and PKM variables (Table 1). These results are similar to those obtained by Bufano et al. (2006) in southern Italy.

This non-significant effect of the season on these variables may be attributed to the animals’ adaptation to the farm’s edaphoclimatic conditions. It can also be indicative of manage-
ment adaptations, mainly to feeding management that allows the animal to maintain its physiological balance and to react positively to climatic variations, and thereby maintain production levels of milk and its components. The year of calving had a significant effect on total daily milk production. These results are similar to those recorded by Sampaio Neto et al. (2005) who observed the influence of year of calving on milk production and found a consistent tendency towards an increase from year to year. The effect of the year was also significant for the mozzarella yield index (PKM), but showed no influence on LSCC (logarithmic somatic cell count), fat, protein or dry extract yield (TDE) (Table 2).

Average daily milk production is used to estimate buffalo productive efficiency. This work showed an overall mean daily milk production of 7.776 kg. This is higher than the 4.07 kg found by Jorge et al. (2005) in Botucatu in Sao Paulo State, the 3.25 kg recorded by Oliveira et al. (2006) in Rio de Janeiro State, the 5.00 kg of milk per day observed by Lamontagna and Franzolim (2009) in Pirassununga, Sao Paulo, and the 4.52 kg found by Macedo et al. (2001) in western Sao Paulo State. However, findings in this study were approximately 15% lower than the value of 9.11 kg/day recorded by Bufano et al. (2006) in southern Italy and 13.87 kg/day for Italian Mediterranean buffalo recorded by Coletta et al. (2007). However, these results were obtained with buffaloes managed in dry lot conditions. Our results are from grazing, and this may suggest a potential for development, mainly through genetic improvement.

The variation in average daily milk production as a function of the year may be due to the management system, climatic factors, such as an increase in sunlight hours per day, and higher rainfall levels. It may also be related to hygienic-sanitary and nutritional management; the former is represented primarily by forage availability and the nutritional value of forage and concentrate supplementation within a specific year. Lugo (2009) studied buffalo herds in a number of Brazilian states and foreign countries, and observed a significant effect of calving year on milk production. This confirms the influence of environmental effects on milk production and milk constituents.

Higher production is generally associated with greater forage availability and dry matter intake by the animals. However, the years with rainfall above the regional mean (835 mm), i.e. 2004 with 1681.7 mm, and 2005 with 1128 mm, obtained the lowest mean daily milk production: 6.927 and 6.870 kg, respectively.

### Table 2. Effect of the year on milk yield, logarithmic somatic cell count, fat, protein, total dry extract and mozzarella yield index.

| Year | Milk yield | LSCC | Fat | Protein | TDE | PKM |
|------|------------|------|-----|---------|-----|-----|
| 2004 | 6.927±0.215 | -    | -   | -       | -   | -   |
| 2005 | 6.870±0.165 | -    | -   | -       | -   | -   |
| 2006 | 8.523±0.132 | -    | -   | -       | -   | -   |
| 2007 | 7.938±0.122 | 2.309±0.055 | 7.054±0.119 | 4.358±0.047 | 16.924±0.184 | 1.790±0.044 |
| 2008 | 8.623±0.135 | 2.338±0.051 | 7.159±0.109 | 4.287±0.043 | 16.946±0.170 | 1.979±0.041 |
| **Mean** | 7.776±0.068 | 2.324±0.037 | 7.107±0.079 | 4.323±0.031 | 16.935±0.122 | 1.885±0.030 |
| **CV, %** | 17.6 | 22.7 | 16.0 | 10.4 | 10.4 | 22.6 |

LSCC, logarithmic somatic cell count; TDE, total dry extract; PKM, mozzarella yield. *Within each variable, means followed by the same letter do not differ (P>0.05) by Tukey 5%.*

Excess soil moisture and air humidity have had a negative impact on dry matter intake due to heat stress and/or increased parasitism by endo- and ecto-parasites. According to Lopes (2009), the rainy season may not result in a need for animal supplementation since pastures are abundant. Dantas et al. (2008) state that an increase in rainfall and relative air humidity causes stress in the animal, due to the threat of insect attacks and change in thermoregulation at this time of the year.

Overall mean fat content was 7.096%: 7.054% and 7.159% in 2007 and 2008, respectively. These values are comparable to those reported by Coelho et al. (2004) 6.838%, Bosquis et al. (2008) 6.87%, and Lopes (2009) 6.999%, and were higher than those described by Jorge et al. (2005) 5.1%, and Lamontagna and Franzolim (2009) 5.49%. However, Oliveira et al. (2006) recorded higher values than those obtained cited here at 8.66% and 8.88%, respectively.

Macedo et al. (2001) showed that wide variations in fat values are to be expected, since fat is the milk component most susceptible to alterations due to a variety of factors, such as genotype, food and nutrition management, lactation stage and calving order.

The relation to mean protein content was 4.320%, ranging from 4.358% in 2007 to 4.287% in 2008; similar results were obtained by Macedo et al. (2001), Coelho et al. (2004), Bosquis et al. (2008) and Lopes (2009).

The mean total dry extract of 9.199% was similar to the 9.01% reported by Macedo et al. (2001), the 17.23% reported by Coelho et al. (2004), and the 16.85% reported by Lopes (2009), and higher than the 13.88% obtained by Jorge et al. (2005), and the 15.2% reported by Lamontagna and Franzolim (2009). Oliveira et al. (2009), using different sources of lipid supplementation, found values of 18.3% to 20.12%, which are higher than those obtained here.

Chemical analyses to determine milk component levels is important for the dairy industry, since these levels interfere directly with the yield and quality of dairy products. It should be pointed out that a variation in fat, protein and dry extract content may generate profit for the farmers and/or milk processors.

The effect of the year on milk production has a direct influence on the mozzarella yield index, as milk volume has greater weight in the yield index formula. In this case, the greater the milk production, the greater the estimated mozzarella production, even if the values of the other components (protein and fat) remain constant.

The PKM index showed a daily mean of 1.891 kg: 1.790 kg for 2007 and 1.979 kg for 2008. These data are similar to production observed in southern Italy by Bufano et al. (2006) and higher than the results obtained by Andrighetto et al. (2005) in Botucatu, San Paolo, where indices ranged between 104.28 kg and 120.70 kg, with 150 days of lactation. They are also greater than the yields of between 394.59 kg and 450.27 kg reported by Campos (2008) in 305-day lactations in Jaboticabal, San Paolo.

Using a bioeconomic model, Seno et al. (2007) found that water buffalo milk production for mozzarella processing purposes is much more lucrative than selling the milk to plant industries; the same observation was described by Lopes et al. (2006) when they made a profitability analysis of a dairy company with an option to commercialize cheese or milk in southern Minas Gerais State.

Means observed for LSCC are similar to the values of 2.35 and 2.17 found by Pardo (2007) in milk samples with a positive California Mastitis Test (CMT). According to classification used by Oliveira et al. (2006) and Mendoza-Sánchez (2007), the SCC obtained in the present study is that of classification 3. It is characterized by a high cell count and results are higher than those obtained by Céron-
The SCC values recorded here are very near to the 400,000 cells/mL (the maximum limit permitted in Europe and New Zealand) reported by Brito and Brito (2001), and below the limit established by the USA and IN51 for northeastern Brazil, which is 750,000 cells/mL.

However, Bastos (2004) showed the need to evaluate not only the number of somatic cells, but also to perform a microbiological examination to determine the types, predominance and functions of the cells present. He also described situations in which SCC exceeding 5,000,000 cells/mL and microbiological examination did not detect mastitis. Moreover, he found a significant difference at sample collection before and after milking, with the largest number of somatic cells found in samples after milking.

Mattos (2006) reported that SCC values are highly variable due to the large number of influencing factors; these include the age of the cow, lactation stage, number of lactations, seasonal and between milking variations (which tend to be higher at the morning milking), management system and animal individuality. Brito and Brito (2001) estimated that from the second lactation onwards, if there is an increase in SCC from 200,000 cells/mL to 400,000 cells/mL it will result in the loss of 0.6 kg of milk per day, or around 180 kg per lactation, considering a 305-day lactation period. But they confirm that a reduction in SS from 400,000 cells/mL to 200,000 cells/mL results in a similar increase in milk production.

The high somatic cell count found in this study can be attributed to several factors, including the female buffalo age. Céron-Muñoz et al. (2002) reported that first calving buffaloes generally have lower SCC, probably because at first calving females are less exposed to environmental mastitis-causing pathogens. Similarly, Mendoza-Sáñchez (2007) observed that older females tend to have longer mammary infections. This produces more extensive lesions in mammary gland tissues, as well as greater natural loss of the mammary gland epithelium, which would explain the higher SCC values.

It is essential to adopt correct cleaning, sanitizing and disinfecting procedures for teats as well as for the equipment and utensils used in milking before, during and after the process. Hygiene standards of all those involved in all stages of the process and of the environment in which animals are handled is also of utmost importance. In addition, the proper collecting procedure must be adopted for sampling milk for SCC analysis and for buffalo drying off in order to treat existing mastitis and prevent future infections.

Considering that an increase in SCC has a negative effect on milk synthesis and production, besides promoting variations in its main components, there is a clear potential for development of management practices. A decrease in SCC will certainly improve milk quality, thereby increasing its value and that of the mozzarella cheese yield.

Conclusions

Calving season had no effect on milk yield, LCCS, fat, protein and TDE contents, PKM. Total daily milk production and mozzarella yield index (PKM) were significantly influenced by year, but not SCC and milk composition of Murrah buffaloes.

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