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Full Length Article

Physicochemical Characterization and Brix in Jersey Cow Colostrum in Tropical Conditions

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Abstract

The objective of this study was to evaluate the nutritional composition (fat, total protein, casein, defatted dry extract, total solids and vitamin A), refractometry and pH of Jersey cow colostrum and correlations between Brix degree and colostrum constituents. Colostrum samples were collected from Jersey cow in the fifth milking after calving. Samples were identified and refrigerated until analysis. Data were subjected to analysis of variance and a descriptive analysis, while differences between milk were compared by the Duncan's test ($P < 0.05$) using the SAS version 9.0 software program. Pearson correlations were then performed between Brix grade and bovine colostrum constituents. The fat, total protein, casein, total solid and Brix percentage of the colostrum gradually decreased from the first to the fifth milking, while the lactose content increased. Positive correlations were observed between Brix values and protein, casein, total solids and defatted dry extract contents, while lactose was negatively correlated. The rapid reduction in Brix means and protein concentrations after delivery demonstrates the importance of administer colostrum in the shortest period after birth. © 2021 Friends Science Publishers

Keywords: Colostrum quality; Nutritional composition; Newborn protection; Passive immunization; Refractometry; immunoglobulin

Introduction

The first food of a newborn mammal is known as colostrum. It is produced by the bovine mammary gland, beginning at the end of gestation and ending a few days after birth (Micinski *et al.* 2017). Colostrum is a food with high nutritional value, abundant in a series of compounds with antimicrobial activities, amino acids and growth factors, and is essential for developing the calf's immune system (Blum and Hammon 2000; Zándoki *et al.* 2006; Sobczuk-Szul *et al.* 2013). The solids composition of colostrum varies between 21–27%, being higher than the 12–13% which is observed for milk (Jaster 2005), and is influenced by the age of the animal, parity, health, nutrition, management, and season, among other factors (Tsioulpas *et al.* 2007).

The absorption of maternal immunoglobulins through colostrum is essential for preventing disease and death of the calf, as calves are hypogammaglobulinemic at birth (Gulliksen *et al.* 2008). Offering colostrum to the newborn should occur as shortly as possible after delivery to ensure high quality of colostrum. These concentrations may decrease by up to 3.7% every h after delivery (Morin *et al.* 2010).

Proper passive immunization of the calf is essential until its immune system develops. Therefore, directly evaluating colostrum immunoglobulin G (IgG) concentration on the farm is recommended (Morrill *et al.* 2015). However, few farms employ equipment for its evaluation (*e.g.*, colostrometer and refractometer) (Vasseur *et al.* 2010; Santos and Bittar 2015; Drikik *et al.* 2018), although they understand the importance of caring for the quality of colostrum.

Immunoglobulin concentrations in bovine colostrum are influenced by the number of milkings after delivery, reducing the immunization efficiency of neonates (Gomes *et al.* 2011). Colostrum has a nutritional composition consisting of necessary fats and proteins for the development of the offspring, in addition to its immunological importance (Angulo *et al.* 2015; Pyo *et al.* 2020).

The objective of this study was to evaluate the

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nutritional composition (fat, total protein, casein, defatted dry extract, total solids and vitamin A), refractometry and potential of hydrogen (pH) of Jersey cow colostrum and the correlations between Brix grade and colostrum constituents from the first to the fifth milking.

Materials and Methods

Herd selection and sample collection

We collected 225 colostrum samples between August 2018 and April 2019 from the first five milkings after calving of Jersey cows belonging to a commercial farm located in São Gonçalo do Amarante - Rio Grande do Norte, Brazil. The climate was classifed as Aw, tropical with a dry season (Köppen-Geiger). The average rainfall in the region during the trial period was approximately 1500 mm per year, an average temperature of 26°C, and average relative humidity of 78.0%, according to data obtained from a meteorological station installed on the farm. The experimental group consisted of 45 animals, 22 primiparous and 23 multiparous managed under a compost barn system.

Individual colostrum samples were obtained per cow, with the first collection performed one h after delivery and the others with a 12-h interval between milking. These samples were collected through mechanical milking and placed in 40 mL plastic bottles, then later stored in isothermal boxes at a temperature of 3° to 7°C and sent to the University's Milk Quality Laboratory Federal of Rio Grande do Norte (LABOLEITE-UFRN).

Physicochemical analysis

Colostrum samples were subjected to analysis by infrared absorption in an instrument (Dairy Spec®, Bentley Instruments Inc., Chaska Minnesota, United States of America) to determine the levels of fat, total protein, lactose, casein, total solids and defatted dry extract. The equipment was calibrated using uncorrected data obtained from standard colostrum samples of jersey cows sent with the equipment, and which were prepared using chemical methods. The colostrum pH was measured using a digital pH meter (Lucademia®, model LUCA-2010, São Paulo, Brazil) calibrated according to the manufacturer's recommendations.

Refractometry

The refractometry analysis was performed using a portable optical sugar refractometer (Kasvi®, model K52-032, measuring range 0 to 32% Brix and minimum division 0.2%) after calibration with distilled water, as recommended by the manufacturer. A drop of colostrum was placed over the refractometer prism with the sample at room temperature and homogenized, and then read through the monocular lens. The Brix result was obtained by separating the light area from the dark area formed on the equipment display after its perpendicular arrangement to light.

Densitometry

The IgG concentration estimation in first milking colostrum was performed by reading the specific gravity using a colostrometer. Approximately 250 mL of room temperature colostrum was transferred to a beaker to which the densimeter was transferred, thereby allowing excess colostrum to overflow through the beaker until the equipment floated. The colostrum density was estimated from the scale just above the unsubmerged part of the densimeter floating freely in the beaker (Fleenor and Stott 1980).

Retinol extraction

Retinol extraction in colostrum was performed using the method of Giuliano *et al.* (1992), with adaptations. First, 1 mL of colostrum was added to light-protected polypropylene tube, and the samples were weighed after homogenization.

Retinol concentration was determined by High Performance Liquid Chromatography (HPLC) on a Shimadzu LC-10 AD Chromatograph, coupled with a Shimadzu UV-VIS SPD-10A Detector and Shimadzu Cromatopac C-R6A Integrator with a C18 LC Shim-pack CLC-ODS (M) 4.6 mm × 25 cm column. The mobile phase used was 100% methanol, with a flow rate of 1 mL/min.

Retinol identification and quantification in the samples were established by comparison with retention times and areas of the respective standards. The pattern concentration was confirmed by the specific extinction coefficient (ε 1%, 1 cm = 1 780) in absolute ethanol and 325 nm wavelength (Nierenberg and Nann 1992).

Statistical analysis

Data were submitted to analysis of variance and a descriptive analysis, while the differences between milk were compared by the Duncan test ($P < 0.05$) using the Statistical Analysis System (SAS) version 9.0 software program. Also, Pearson correlations were performed between Brix grade and bovine colostrum constituents.

The general mathematical model used was: $y_{ij} = \mu + t_i + \varepsilon_{ij}$, in which: y_{ij} = dependent variables (physicochemical constituents of milk); μ = overall mean; t_i = effect of the i^{th} treatment; ε = residual effect.

Results

Physicochemical composition of colostrum

The results from evaluating the physicochemical components of Jersey cows' colostrum in its first milking after calving are shown in Table 1. A difference ($P < 0.05$)

for the fat percentage was observed among the evaluated milkings, with higher values found for the first milking (5.78%) and lower values for the fifth milking (2.97%).

The protein fraction of colostrum showed statistical differences among the evaluated milkings, with a rapid decrease in the values of the first milking (22.63%) to the fifth (6.72%).

Following the results verified for total protein, there was a reduction in colostrum casein ($P < 0.05$) with the advancing lactation, with values of 18.75% for the first milking and 5.67% for the fifth milking. There was a rapid decrease in its concentration between the first and third milking (12.07%) with a decrease of 6.68%.

In contrast to the other components, lactose presented lower concentration in the first milking (1.09%) and gradually increased until the fifth (2.48%).

Significant differences ($P < 0.05$) were observed for the total solids means among the evaluated milkings, with the first milking colostrum presenting the highest value (31.33%), while the fifth milking colostrum presented the lowest (13.43%).

No statistical differences ($P < 0.05$) were observed for vitamin A concentrations in the different milkings.

Refractometry and pH in colostrum

Brix values were gradually reduced from the first (29.45%) to the fifth (13.94%) milking (Table 2).

As can be seen in Fig. 1, strong positive correlations were found between Brix values and protein, casein, total solids and non-fat dry matter (NFDM).

Discussion

A difference ($P < 0.05$) for the fat percentage was observed among the evaluated milkings. Means for first milking near 5.3% for the fat percentage were observed by Morrill *et al.* (2012) for Jersey cows' colostrum.

The reduction in colostrum fat fraction with advancing lactation was also reported by El-Fattah *et al.* (2012) and Micinski *et al.* (2017); however, the latter found rates of 7.12% for the first milking and 5.90% for the third day of lactation, constituting higher values than those observed in the present study. Contarini *et al.* (2014) described increased concentration of fat levels with advancing lactation.

The protein fraction of colostrum showed statistical differences among the evaluated milkings, with a rapid decrease in the values of the first milking to the fifth. The protein values observed in the present study were higher than the 17.5% reported by Sobczuk-Szul *et al.* (2013) for protein in Jersey cows' colostrum in the first milking after calving. The means in the present study were also higher than the findings of Micinski *et al.* (2017), in which the authors reported concentrations of 15.13% in the first milking, 9.19% in the second milking, and 4.51% on the third day of lactation in confined Holstein colostrum. The high protein concentration in this period may related to the higher amount of casein and immunoglobulins (IgG, IgA and IgM) in colostrum, as these immunoglobulins have the function of protecting the calf from diarrhea and other gastrointestinal diseases which represent more than 62% of mortality cases in newborns (Baumrucker *et al.* 2010; Oliveira *et al.* 2018).

A reduction in colostrum casein with the advancing lactation and a rapid decrease in its concentration between the first and third milking were also reported by Madsen *et al.* (2004). However, more detailed studies show that the different casein fractions may vary differently; in this sense, Sobczuk-Szul *et al.* (2013) reported increased α-casein on the second day of lactation, reduced κ-casein and maintenance of constant *β*-casein during the colostral period.

The gradual increase in lactose confirms the behavior reported in studies conducted by Conte and Scarantino (2013) and El-Fattah *et al.* (2012) in analyzing the colostrum behavior in Dutch cows. El-Fattah *et al.* (2012) reported an increase in lactose values during lactation. In a study with confined Dutch cattle, Micinski *et al.* (2017) observed averages of 2.77% for lactose in the first milking after delivery, 3.57% for the second milking, and 3.94% for third day colostrum.

The low lactose values in colostrum are interesting for calf digestion, as their body has difficulty digesting sugars, causing animals to have diarrhea (Lang 2008). Unlike other colostrum components, lactose synthesis tends to increase over the course of lactation, and then stabilizes within 5 days after delivery (Nakamura *et al.* 2003). The viscous characteristic and low amount of colostrum water is related to its low lactose concentration, which according to Bleck *et al.* (2009), acts as an osmoregulatory agent, since its synthesis causes water transfer from the cytoplasm of mammary epithelial cell to the secretory vesicles and consequently to milk (Fox and Kelly 2006).

The significant reduction in total solids between the evaluated milkings reflects the gradual decrease over time for the fat, total protein and casein percentages, as reported by El-Fattah *et al.* (2012). In a study conducted by Sobczuk-Szul *et al.* (2013) comparing colostrum samples from Jersey and Holstein cows, it was observed that total solids and defatted dry extract percentages in the first milking after calving were higher for Jersey animals, which obtained an average of 28.47% for total solids and 23.34% for defatted dry extract. In a similar study, Morrill *et al.* (2012) observed 23% values for total solids in Jersey cows' colostrum.

No statistical differences were observed for vitamin A concentrations in the different milkings; however, the values of 369.3 (IU/dL) for the first milking, 480.7 (IU/dL) for the second milking, and 488.8 (IU/dL) for the third milking observed in the present study were higher than the values of 250.0 (IU/dL), 270.83 (IU/dL) and 312.5 (IU/dL) for the colostrum of the first three milkings from Dutch cows (El-Fattah *et al*. 2012).

Table 1: Physicochemical composition of colostrum (mean ± SD)

Milking	Fat (%)	Protein (%)	Casein (%)	Lactose (%)	Total solids (%)	Non-fat dry matter (%)	Vitamin A (UI/dL)
1	5.78^{a} ± 0.51	22.63^{a} ± 1.62	18.75^{a} ± 1.37	1.17^{c} ± 0.18	31.33^{a} ± 1.88	23.61^{a} ± 1,80	369.3 ± 333.91
2	2.85^{bc} ± 0.51	20.93^{a} ± 1.75	16.64^{a} ± 1.39	1.06^{c} ± 0.17	25.67^{b} ± 1.77	22.82^{a} ± 1.67	480.7 ± 07.97
3	4.05^{ab} ± 0.56	15.20^{b} ± 1.28	12.07^{b} ± 1.03	1.48^{c} ± 0.27	21.52^{bc} ± 1.79	17.46^{b} ± 1.40	488.8 ± 35.78
4	3.37^{bc} ± 0.66	10.91^{c} ± 1.10	8.66^{bc} ± 0.88	1.76^{bc} ±0.41	16.68cd ±1.26	13.29^{bc} ± 0.88	268.2 ± 06.46
5	2.97^{bc} ± 0.75	6.72^{cd} ± 0.64	5.67^{cd} ± 0.57	2.48^{b} ± 0.38	13.43^{d} ± 1.06	10.39^{c} ± 0.43	204.8 ± 89.58

SD: Standard deviation. Averages with distinct letters in the same column differ from each other by the Duncan test ($P < 0.05$)

Table 2: Brix (%), pH values in Jersey cow colostrum (x ± SD)

Milking	1st	2nd	3rd	4th	5th
Brix (%)	29.45^{a} ± 0.65	26.19^{b} ± 0.92	20.28^{c} ± 0.99	16.16^{d} ± 0.61	13.94^{e} ± 0.59
pH	6.23^{a} ± 0.19	6.54^{a} ± 0.14	6.62^{a} ± 0.09	6.58^{a} ± 0.09	6.48^{a} ± 0.16

SD = Standard deviation. Averages with distinct letters on the same line differ from each other by the Duncan test ($P < 0.05$)

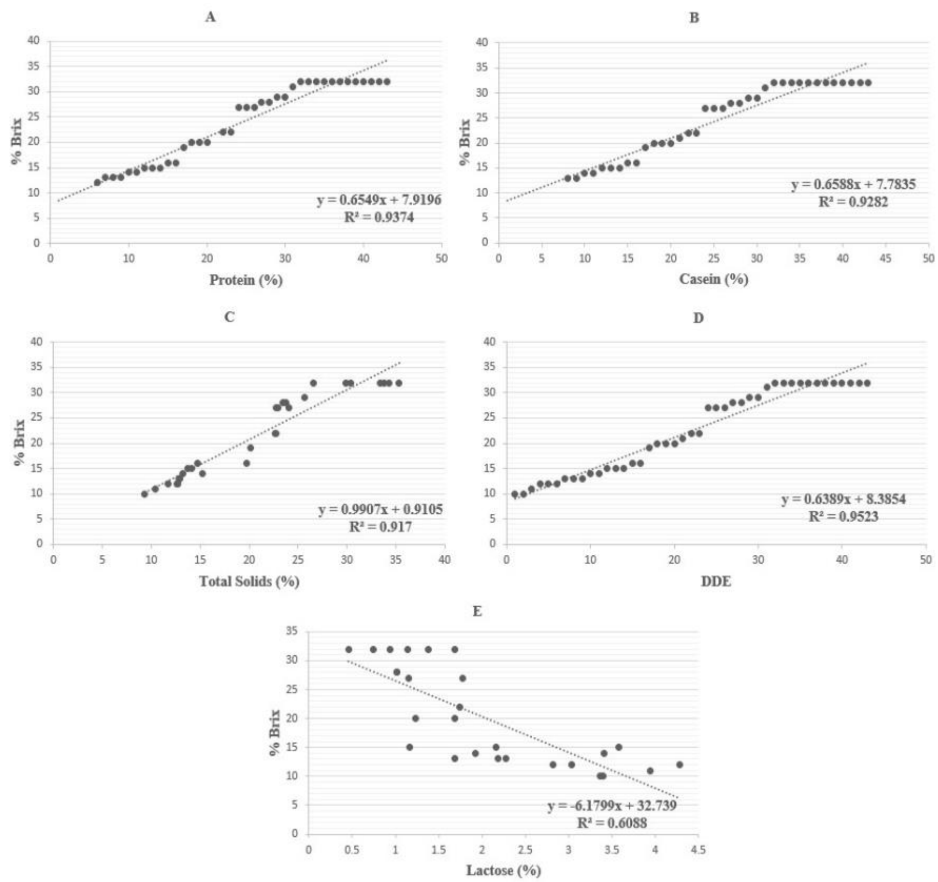

Fig. 1: Pearson correlations between Brix grade and bovine colostrum constituents: **A**) Protein; **B**) Casein; **C**) Total Solids; **D**) DDE; **E**) Lactose

In a study conducted by El-Fattah *et al.* (2012), as well as in the present study, we could observe an increase in vitamin A values in the second and third milking after birth, which follows an increasing behavior of these components at the beginning of the colostrum period, which may be related to the decrease in the immunoglobulin levels. As noted by El-Fattah *et al.* (2012), there was a decrease in these levels for the third day colostrum, in which the authors reported values of 159.63 (IU/dL), constituting lower values than the 203.5 (IU/dL) observed in the current study.

The 105.71 ± 5,23 (mg/mL) IgG values for the density reading in the first milking colostrum observed in the present study are higher than the 84.49 (mg/mL) reported by Morril *et al.* (2015) for measuring IgG in fresh Jersey cow colostrum.

In a study aimed at evaluating the use of refractometer and colostrometer to determine colostrum quality, Bartier *et al.* (2015) reported that although the colostrometer overestimates IgG concentration, it can be used on farms, provided that a cut-off point of 80 mg/mL is employed.

Colostrometer use is uncommon on farms, despite recommendations to do so. In order to know the management practices adopted in 174 dairy farms in the states of São Paulo, Minas Gerais and Paraná, Santos and Bittar (2015) observed that only 7.4% of the breeders are using a colostrometer or refractometer for evaluating colostrum quality.

The amount of immunoglobulins present in colostrum influences the newborn's immunization, so it is usually reduced during lactation as the animal develops its own immune system (Morrill *et al.* 2015). Thus, it is important that the producer has such knowledge to favor management which ensures an adequate colostrum supply to the newborn calf.

The immunoglobulin concentration may be represented by the light refraction obtained by Brix (Chavatte *et al.* 1998). Colostrum obtained shortly after delivery in the present study exceeds the mean Brix (21.24%) reported by Morrill *et al.* (2015), and the average of 23.8% observed by Quigley *et al.* (2013). According to McGuirk and Collins (2004) and Silva-del-Río *et al.* (2017), high quality colostrum with values greater than 50mg IgG/mL when refractionally evaluated has 21% Brix values.

Morrill *et al.* (2015) suggested the use of colostrum with values equal to or greater than 21% for Holstein cows and 18% for Jersey cows; thus, it can be sad that the values observed for the first (29.45%), second (26.19%) and third milking (20.28%) in the present study meet the requirements of the IgG values for high quality Jersey colostrum.

Strong positive correlations were found between Brix values and protein, casein, total solids and non-fat dry matter (NFDM). According to Chavatte *et al.* (1998), a refractometer can capture the refraction of protein molecules (immunoglobulins and casein) in light, serving as an estimate for the amount of protein in colostrum, which influences the concentrations of total solids and NFDM.

Thus, the negative correlation between Brix and lactose in Fig. 1 (E) is due to the inverse behavior of lactose and the other colostrum constituents, with lactose being the only component which increased concentration during lactation until reaching mature milk values.

Conclusion

In conclusions, the fat, total protein, casein, total solids, NFDM, and the Brix percentage of colostrum gradually decreased from the first to the fifth milking, while the lactose content increased. Positive correlations were observed for Brix values and protein, casein, total solids and defatted dry extract contents and negative correlation with lactose. The rapid reduction in Brix means and protein concentrations after delivery demonstrates the importance of colostration offering in the shortest period possible after birth. The observed Brix values for the studied herd suggest that the colostrum of Jersey cows can be used for colostrum bank production up to the third milking.

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Author contributions

EGSOS and AHNR conceptualization, EGSOS, MFB, AHNR and SAU, methodology, EGSOS, IMB and MFB formal Analysis, EGSOS, IMB, MFB, JPFO, SAU, LHFB and DMLJ investigation, LHFB data curation, EGSOS writing – original draft preparation, EGSOS, JPFO, AHNR, SAU, MFB, CSM, DMLJ, MASG and KA writing – review & editing, AHNR supervision. All authors have been involved in commenting on and reviewing the manuscript.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Data Availability

All the data related to this study is included in the article, further inquiries can be directed to the corresponding author.

Ethics Approval

The project which originated this study was submitted to the Animal Use Ethics Committee of Federal University of Rio Grande do Norte (CEUA-UFRN), being approved for legal implementation (protocol 098.023/2018), in accordance with Law No. 11,794, 2008.

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