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Chemical composition and immune status of dairy goat colostrum fractions during the first 10 h after partum☆

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ABSTRACT

The objective of this study was to examine the chemical and immunological quality of goat colostrum following delivery. Twenty dairy goats of the Majorera breed were milked 1 h postpartum and then every hour for 10 h after the first milking. Residual colostrum (RC) was also obtained at the time of the first milking after i.v. injection of 2 I.U. of oxytocin. Colostrum yield, approximate composition, SCC, IgG, IgM, IgA and chitotriosidase activity were measured in milking colostrum (MC), RC, and colostrums in each hour sample. A PROC MIXED procedure was performed and a Tukey's test was done to determine the statistical significance of differences in the composition of the colostrum fractions and the colostrum obtained over time. At the first milking, MC and RC weighed 2506 and 237 g, respectively. At 1 h and 10 h after the first milking, the colostrum yield was 174 and 120 g, respectively, with a continuous drop in yield over the course of the experiment. A drop in protein production was also seen over time. Colostrum protein percentages were 10.4 and 10.2 in MC and RC. Colostrum protein percentages at 1 and 10 h after first milking were 9.7% and 4.5%, respectively. The percentage of colostrum fat increased 1 h after the first milking and then decreased to 6.1% at 10 h after the first milking. The lactose colostrum percentage displayed an increase during the experimental period. Colostrum SCC was not affected by colostrum fractioning or time, with a range of 4.2–5.8 $\times 10^6$ cells/mL. IgG, IgM, IgA levels and chitotriosidase activity did not present differences between colostrum fractions at the first milking but displayed a drastic drop in subsequent milkings. In sum, the chemical and immunological quality of colostrum dropped quickly after the first milking, and thus goat keepers need only recover the first milked colostrum when they rear goat kids separately from dams.

1. Introduction

Colostrum, which is the first milk consumed by the newborn formed and stored in the mammary gland during late pregnancy (Linzell and Peaker, 1974), is necessary for goat kids due to they are agammaglobulinemic at birth and therefore need to consume colostrum during the first hours after birth, as this is their principal IgG source during the first month of life (Argüello et al., 2004b; Keskin et al., 2007). Argüello et al. (2004a) demonstrated the relationship between IgG blood concentration and goat kid survival, finding that at 24 h of age healthy kids display double the concentration of IgG as animals that die during the first week of life. Otherwise colostrum quality knowledge is necessary when kids are raised under artificial rearing (Argüello et al., 2004c).

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Colostrum and milk contain fat, proteins, lactose and minerals, which are all of nutritional importance. In addition, they contain vitamins, immunoglobulins, hormones, growth factors, cytokines, enzymes and bioactive peptides (Swaisgood, 1995; Blum and Hammon, 2000); metabolites derived from alveolar epithelial cells (Peaker and Linzell, 1975) and immunocompetent cells (Lee et al., 1980). Argüello et al. (2008) recently also demonstrated the high activity of the component of the innate immunity the enzyme chitotriosidase in colostrum.

In artificial rearing management practices used in intensive dairy production, kids must be separated from dams after parturition in order to minimize or annul the mother–kid link, which is established in the first hours after birth (Ramírez et al., 1996). This practice facilitates the acceptance of artificial nipples by the kid, thus improving the adoption of formula feeding.

Castro et al. (2005) and Rodríguez et al. (2009) have demonstrated the role of immunoglobulin colostrum concentration in passive immune transfer to newborn goat kids. IgG_1 is though to be specifically transported by a process of transcytosis across the mammary epithelial cells during colostrogenesis (Baumrucker et al., 2010), while the absorption by the kids is mediated by apoptotic enterocytes (Castro-Alonso et al., 2008). Thus, knowledge of colostrum chemical composition is necessary to improve newborn management. In day-two cow colostrum, Ontsouka et al. (2003) observed that chemical composition varies in different colostrum milk fractions. Bergman and Turner (1937) described the daily evolution of goat colostrum composition, and Argüello et al. (2006) observed the influence of the number of daily milkings and litter size on chemical composition and physical characteristics of goat colostrum.

Colostrum and milk components are secreted by different mechanisms (Patton and Jensen, 1975). Secretion is regulated by both local and systemic factors. In a practical sense, colostrum comprises two fractions, namely milking colostrum (MC) that is procured during milking, and residual colostrum (RC) that remains in the udder after milking. The RC will be part of colostrum milked on the second day following delivery. No information is available about the quantity or quality of RC or concerning colostrum amount and quality after the first milking. Usually colostrum is obtained from the first and second milkings postpartum and conserved for goat kid colostrum feed. Under the hypothesis that there are also continuous changes in colostrum composition between the first and second milking, the objective of this study was to measure the concentration of nutritional and non-nutritional milk components in MC and RC and colostrum milk samples during the 10 h after the first milking.

2. Materials and methods

Experimental animal procedures were approved by the Ethical Committee of the Universidad de Las Palmas de Gran Canaria. Twenty dairy goats of Majorera breed were fed in accordance with INRA suggestions (Jarrige, 1990). In short, feed consisted of corn, soya 66, dehydrated lucerne, dehydrated beetroot, wheat straw and a vitamin–mineral corrector. Oestrous cycles were synchronized by insertion of an intra-vaginal sponge containing fluorogestone acetate (45 mg; Chronogest®, Intervet, Spain) for 11 days, followed by administration of a PGF2α analog (7.5 mg; Prosolvin®, Intervet, Spain) 48 h before sponge removal. After sponge removal, oestrous was assessed twice a day with uncastrated bucks. The goats were mated at 12-h intervals throughout the oestrous period. At 1 h postpartum, teats were prepared cleaning the severe dirt with cotton gauzes, goats were milked, the MC was weighed, and a 100-mL sample was obtained for analysis. An additional fraction was collected and weighed during removal of RC after i.v. injection of 2 I.U. of oxytocin. Then, goats were milked every hour from 1 h to 10 h postpartum, and milk samples were obtained for analysis.

2.1. Laboratory procedures

Fat, protein, and lactose colostrum contents were determined by routine laboratory procedures using an automated infrared method with a DMA2001 Milk Analyzer (Miris Inc., Uppsala, Sweden). SCC was determined using a somatic cell counter (DeLaval International AB, Tumba, Sweden) as Berry and Broughan (2007) demonstrated, immediately after samples were obtained. A soak time of 1 min was employed before cell counting.

Quantification of Ig in colostrum was performed using goat IgG, IgA and IgM ELISA kits (Bethyl Laboratories, Montgomery, TX). Chitotriosidase (ChT) activity was measured as described by Argüello et al. (2008). In short, 1 μL of undiluted colostrum was incubated with 100 μL of a solution containing 22 mM of an artificial substrate (4-methylumbelliferyl-d-N,N′,N″ triacetylchitotriose) in 0.5 M citrate–phosphate buffer, pH 5.2, for 15 min at 37 °C. The reaction was stopped with 5 mL of 0.5 M Na_2CO_3–$NaHCO_3$ buffer, pH 10.7. Fluorescence was measured with a fluorimeter (Perkin Elmer, Norwalk, CT) at 365 nm excitation and 450 nm emission. ChT activity is expressed as nanomoles of substrate hydrolyzed per milliliter per hour.

2.2. Statistical analysis

Statistical analyses were performed using SAS, Version 9.00 (SAS Institute Inc., Cary, NC). The SAS PROC MIXED procedure for repeated measurements was used to evaluate the effect of colostrum fraction and time following first milking on the colostrum chemical composition and immune status. Tukey's test was used to evaluate differences between groups.

3. Results

Table 1 shows the colostrum yield, chemical composition, and SCC in MC, RC and colostrum for each experimental time point. Obviously, the highest milk yield was at time zero; however, during the 10 h after delivery the milk yield of the colostrum milks shows two stages: from 1 to 3 h and from 4 to 10 h. For the first 3 h, milk production was higher than from the second stage.

Protein colostrum percentages were similar in both colostrum fractions. After the initial milking, that protein percentage dropped rapidly from 9.7% at 1 h to 4.5% at 10 h postpartum. Relative to the fat content, this was slightly higher for the residual colostrums than the cisternal colostrum, although the highest fat percentage was at 1 h after the first milking, maintaining higher values until the 3 h as in protein. However, the lactose percentage followed opposite pattern being the smallest value in the milking colostrums and the highest value at 10 h postpartum. There are no effects of colostrum partitioning (MC vs. RC) or time after partum on colostrum SCC levels.

In Table 2, the measured values of IgG, IgM, IgA and ChT activity are shown. IgG concentration was similar in MC and RC. After the first milking, the IgG concentration dropped rapidly in the first 10 h following delivery. The pattern of IgA and IgM concentrations in colostrum was similar to the IgG pattern, although the values dropped dramatically the second hour.