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Intramammary administration of lipopolysaccharides at parturition does not affect the transfer of passive immunity in goat kids.

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ABSTRACT

This study evaluated the effect of feeding colostrum obtained from an intramammary administration (IA) of LPS from *Escherichia coli* (O55:B5) to dairy goats at parturition, on goat kids performance, biochemical parameters (i.e., calcium, LDH, glucose, total proteins, albumin, and urea) and immune status (i.e., IgG and IgM) during the first month of life. At birth, goat kids were weighted (d 0) and immediately allocated into either the LPS group (n = 15) or the CON group (n = 21) based on the experimental group of the dam. At parturition, 20 multiparous dairy goats were allocated in one of the 2 experimental groups (LPS vs. CON). The LPS group received an IA of saline solution (2 mL) containing 50 µg of LPS in each half udder whereas goats in the CON group received an IA of saline solution (2 mL) without LPS. Goat kids were bottle-fed dam colostrum equivalent to 10% of the birth BW divided in 2 meals (i.e., at 3 and 12 h relative to birth), and then fed twice daily with milk replacer ad libitum. Individual milk intake (MI) and BW were recorded on d 7, 15, 21 and 30 of life. Blood samples were collected on d 0, 1, 2, 4, 7, 15, 21 and 30 after birth. Data was analyzed using the MIXED procedure of SAS (9.4). The model included IA, time (T) and the interaction (IA x T) as fixed effects and sex and litter size as random effects. Both groups showed similar MI, except on d 7 relative to birth as the LPS group showed higher MI than the CON group (910.5 ± 69.77 and 683.9 ± 59.64 mL, respectively). No differences in BW or rectal temperature were observed between groups, neither in plasma IgG nor IgM concentrations. Despite the IA did not affect calcium, glucose, LDH, total protein, and al-

bumin concentrations an interaction between the IA and T was observed for urea concentration, showing the LPS group higher urea concentrations than the CON group on d 0 (20.1 ± 1.34 and 20.0 ± 1.25 mg/dL, respectively). In conclusion, feeding colostrum from goats that received an IA of LPS at parturition does not affect goat kid performance, plasma immunoglobulin concentrations and serum metabolites during the first month of life.

Keywords: immune, dairy, growth, performance

INTRODUCTION

During gestation, ruminant placenta does not allow the sufficient transfer of immune components to the fetus (Stelwagen et al., 2009; Hernández-Castellano et al., 2015b). Thus, goat kids are born without enough maternal immune factors, relying on colostrum consumption to face infectious and non-infectious challenges after birth (Besser and Gay, 1994; Weaver et al., 2000). Besides nutrients, colostrum contains other bioactive molecules such as hormones, immunoglobulins and antimicrobial peptides that have an important role in the protection and the muscle and gastrointestinal development of the newborn animal (Pakkanen and Aalto, 1997; Hernández-Castellano et al., 2014).

Colostrum quality has traditionally been determined by the immunoglobulin concentration, mainly immunoglobulin G (IgG). In goat colostrum, the IgG concentration is about 2.4 times greater than in blood serum (Micusan and Bord, 1977). There are 2 IgG subclasses (i.e., IgG₁ and IgG₂). The IgG₁ is mainly transferred from the bloodstream by a receptor mediated pathway and represents about 95–98% of total colostrum IgG (Korhonen et al., 2000). The IgG₂ is mostly recycled within the tissue but can be also transferred to colostrum in much lower rates (Baumrucker et al., 2021). Both isotypes are also synthesized by immune cells in the mammary gland, increasing its synthesis during natural and induced inflammation (Wellnitz et al., 2013; Alnakip et al., 2014). Besides im-

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The list of standard abbreviations for JDS is available at adsa.org/jds-abbreviations-24. Nonstandard abbreviations are available in the Notes.

munoglobulins, colostrum also contains a wide variety of non-immunoglobulin proteins that play a fundamental role in the activation of the immune system. In ruminants, colostrum quality is directly associated with newborn survival (Hernández-Castellano et al., 2015a) and depends on multiple factors such as species (Kessler et al., 2019), the nutritional status of the dam (Banchero et al., 2004a; Banchero et al., 2004b), management system (Castro et al., 2011), and udder health (Alcindo et al., 2023), among others.

During either natural or induced udder inflammation (i.e., mastitis), the selective transfer of IgG₁ to colostrum is reduced whereas there is a marked increase of other proteins, such as IgG₂ or serum albumin (Lascelles A.K., 1979) and an infiltration of blood neutrophils, T-lymphocytes and macrophages which release cytokines (i.e.: TNF- α , IL-1, IL-2 or IL-6) within the mammary tissue (Burton and Erskine, 2003; Kusebauch et al., 2018). This inflammatory response can lead to changes in the permeability of the blood-milk barrier (**BMB**) causing the leakage of blood components into milk (Wall et al., 2016; Bruckmaier and Wellnitz, 2017).

Gram-negative bacteria are ubiquitous pathogens commonly involved in mastitis (Wellnitz et al., 2011). Their cell wall contains molecules such as LPS that have been widely used in Holstein cows (Lehmann et al., 2013; Gross et al., 2020), sheep (Castro-Costa et al., 2014) and goats (Salama et al., 2020; González-Cabrera et al., 2024) to stimulate the immune system and simulate a sterile mastitis. In fact, changes in the milk proteome in response to an intramammary administration (**IA**) of LPS in dairy goats have been characterized, showing that antimicrobial and acute phase proteins such as cathelicidin-1 and -3, lactoferrin, haptoglobin and serum amyloid A are increased in milk after the IA of LPS (Olumee-Shabon et al., 2013). In addition, other studies have shown that feeding milk containing LPS (i.e., 12 μ g/kg of BW) to dairy calves does not trigger a systemic immune response (Samarasinghe et al., 2020).

Currently, the effect of feeding colostrum from goats challenged with an IA of LPS at parturition on goat kid performance, immune status and blood metabolites has not been evaluated. In this study, it is hypothesized that feeding colostrum from goats treated with an IA of LPS at parturition enhances the immunity acquired by the offspring. Therefore, this study aimed to assess the effect of feeding colostrum from goats challenged with an IA of LPS at parturition on goat kid performance, immune status, and blood metabolites.

MATERIALS AND METHODS

Experimental design

The present experiment was conducted in the experimental farm located in the Veterinary Faculty at the Universidad de Las Palmas de Gran Canaria (Aruca, Spain). The experiment was approved by the Ethical Committee for Animal Experimentation (OEBA-ULPGC; Procedure 28/2021).

The experimental design has been previously described in González-Cabrera et al. (2024). In brief, 20 multiparous *Majorera* dairy goats were randomly assigned to one of the 2 experimental groups (**LPS** vs. **CON**). Goats from the LPS group received an IA consisting of 50 μ g of LPS (*Escherichia coli* serotype O55:B5, Sigma-Aldrich, St. Louis, MO) diluted in 2 mL of saline solution 0.9% in each half udder immediately after parturition, whereas goats from the CON group received an IA with 2 mL of 0.9% saline solution in each half udder without LPS. Teat openings were disinfected with 70% ethanol and then a 1.0 \times 130 mm sterile catheter (Buster Cat Catheter, Kruse, Norway) was used for the IA.

In this study, the average litter size was 2.31 ± 0.56 kids. Single and twin-born goat kids with a birth BW >2.3 kg were enrolled in the experiment, which started at birth and finished at wk 4 of life. All animals were visually healthy and immediately removed from dams before colostrum suckling. Thirty-six goat kids were allocated into the LPS group (n = 15) or the CON group (n = 21) immediately after birth based on the experimental group of the dam. Each animal was bottle-fed with colostrum (10% of the birth BW) milked from the dam 3 h after the IA of LPS in 2 meals (i.e., at 3 h and 12 h relative to birth). After that, animals were fed twice daily with a commercial milk replacer formulated for goat kids (Bacilactol Cabritos, Saprogal, La Coruña, Spain; 95.5% dry matter, 23.6% crude protein and 22.7% ether extract) at 16% (wt/wt) according to Argüello et al. (2004a).

Blood sampling

Blood samples were collected immediately after birth before colostrum intake (d 0) and then on d 1, 2, 4, 7, 15, 21 and 30 relative to birth. Samples were taken via jugular venipuncture with 5 mL syringes (Injekt Braun, Braun, Germany) and 22G needles (Sterican Braun, Braun, Germany). Samples were immediately transferred to EDTA-K2 tubes (BD Vacutainer®, United Kingdom) for plasma collection, and serum tubes (SEROTUB, Deltalab, Spain). Plasma tubes were placed on wet ice immediately after collection and centrifuged at $2,190 \times g$ for 5 min at 4°C (Hettich-Zentrifugen, Universal 32 R, Tuttlingen, Germany). Serum tubes were stored at room

temperature for 2 h and then centrifuged at $2,190 \times g$ for 5 min at 4°C . Both plasma and serum were aliquoted in 1.5 mL Eppendorf Tubes (Flex-Tube, Eppendorf, Germany) and stored at -20°C until laboratory analysis.

Variables

Rectal temperature (RT) and BW were recorded on d 0, 7, 15, 21 and 30 relative to birth. Individual milk intake (MI) was recorded on d 7, 15, 21 and 30 relative to birth. Blood plasma IgG and IgM concentrations were measured using commercial ELISA kits (Bethyl Laboratories, Montgomery, TX, USA). The intra-assay coefficients of variation were 5.4 and 4.3%, respectively. The inter-assay coefficients of variation were 5.3 and 2.8%, respectively. Concentrations of glucose (GN45126, RAL laboratories, Barcelona, Spain), calcium (GN12125, RAL laboratories, Barcelona, Spain), lactate dehydrogenase (LDH; GN42125, RAL laboratories, Barcelona, Spain), total proteins (GN46125, RAL laboratories, Barcelona, Spain), albumin (GN86125, RAL laboratories, Barcelona, Spain) and urea (GN70125, RAL laboratories, Barcelona, Spain) were measured on blood serum using an automatic spectrophotometer (METROLAB 2300GL, RAL Laboratories, Barcelona, Spain). The intra-assay coefficients of variation were 2.10, 1.10, 1.92, 0.90, 0.50 and 2.79% respectively. The inter-assay coefficients of variation were 3.09, 2.16, 3.10, 1.43, 0.80 and 2.65% respectively.

Statistical analysis

Data was analyzed using the MIXED PROCEDURE of SAS (version 9.4, SAS Inst. Inc., Cary, NC). The model included the IA (LPS vs. CON), time (T; from birth to d 30 of life) and the interaction between both (IA \times T) as fixed effects, and litter size and sex as random effects. The animal (goat kid) was considered as an individual subject and time as a repeated measure. The Bonferroni test was used to determine significant differences ($P < 0.05$). The homogeneity of the variance and the normality of the residuals were estimated graphically using PROC UNIVARIATE. Data for variables that did not meet these criteria were log-transformed (\log_{10}) to get normal distribution of residues and homogeneity. Results are presented as LSM \pm SEM. Results that were log-transformed and then back-transformed are presented as Mean [Minimum and Maximum].

RESULTS

The present results should be considered in the context of the companion article (González-Cabrera et al., 2024) that reported differences between the colostrum obtained

from the LPS and the CON group. Briefly, goats from the LPS group showed greater somatic cell count in colostrum than the CON group (3.5 ± 0.09 and 3.1 ± 0.09 cells $10^6 / \text{mL}$, respectively). Similarly, the LPS group showed higher colostrum IgG and IgM concentrations (45.3 ± 4.43 and 0.8 ± 0.08 mg/mL, respectively) than the CON group (28.0 ± 4.50 and 0.5 ± 0.08 mg/mL, respectively). However, the IA of LPS did not affect colostrum chemical composition (i.e., fat, protein, lactose, and total solids).

In the present study, an interaction between the IA and time was observed for MI (Table 1; Figure 1; $P_{\text{IA} \times \text{T}} = 0.002$). Goat kids from the LPS group showed higher MI than the CON group on d 7 (836.8 ± 94.35 and 764.3 ± 72.13 mL, respectively) whereas no differences were observed over the rest of the experiment. Both, BW and RT were not affected by the IA (Table 1; $P_{\text{IA}} \geq 0.172$) but were affected by time ($P_{\text{T}} < 0.001$). Body weight increased progressively from birth (d 0) to d 30 (3.0 ± 0.20 and 7.0 ± 0.20 kg, respectively), along with RT which also increased from d 0 to d 30 (38.7 ± 0.07 and $39.3 \pm 0.06^{\circ}\text{C}$, respectively).

Plasma IgG concentration in goat kids was not affected by the IA (Table 1; Figure 2A; $P_{\text{IA}} = 0.096$), but was affected by time ($P_{\text{T}} < 0.001$). Immunoglobulin G concentration increased from birth (d 0) to d 4 (0.9 ± 1.40 and 12.8 ± 1.38 mg/mL, respectively), then decreased progressively until d 15 (9.6 ± 1.40 mg/mL) and no differences were observed for the rest of the experimental period. Similarly, plasma IgM concentration was not affected by the IA (Table 1; Figure 2B; $P_{\text{IA} \times \text{T}} = 0.300$). However, IgM concentration increased from birth (d 0) to d 1 (10.7 [$8.4 - 13.7$] and 1035.6 [$623.4 - 1720.1$] $\mu\text{g}/\text{mL}$, respectively) to decrease constantly until d 30 (284.4 [$172.2 - 469.8$] $\mu\text{g}/\text{mL}$).

Calcium, glucose, LDH, total protein and albumin concentrations in goat kids (Table 1) were not affected by the IA ($P_{\text{IA}} \geq 0.075$) but were affected by time ($P_{\text{T}} < 0.001$) except for calcium concentration ($P_{\text{T}} = 0.232$). Glucose concentration increased progressively from birth (d 0) to d 30 (36.4 ± 5.94 and 107.9 ± 4.40 g/dL, respectively). Serum LDH activity increased from birth (d 0) to d 1 (523.5 ± 66.78 and 636.9 ± 67.36 U/L, respectively) and then decreased until d 4 (366.3 ± 67.92 U/L) to increase progressively until d 30 (840.7 ± 65.69 U/L). Similarly, total protein concentration increased from d 0 to d 1 (4.3 ± 0.16 and 5.6 ± 0.16 g/dL, respectively), decreasing until d 15 (4.7 ± 0.15 g/dL) and remaining constant until the end of the experimental period. Albumin concentration decreased from birth (d 0) to d 4 (2.3 ± 0.08 and 1.9 ± 0.08 g/dL, respectively) and then increased constantly until d 30 (2.6 ± 0.08 g/dL). Besides, an interaction between the IA and time was observed for urea concentration (Figure 3E; $P_{\text{IA} \times \text{T}} = 0.001$). Goat kids from the LPS group showed higher urea concentrations than the CON

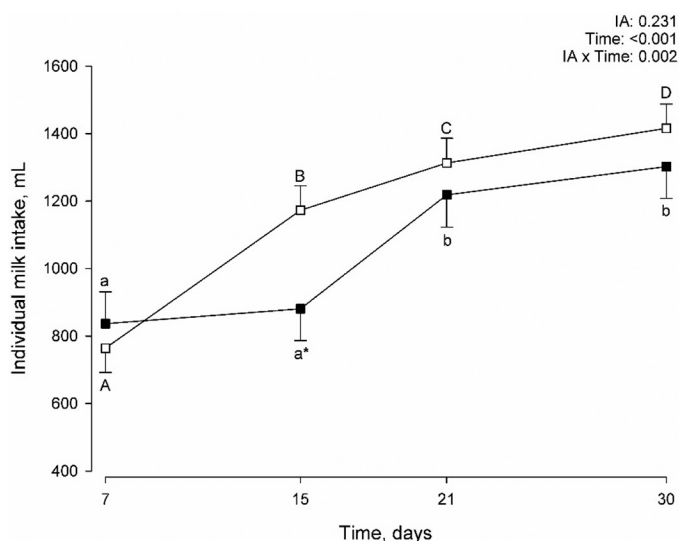


Figure 1. Individual milk intake (MI) in the LPS (■) and CON (□) groups throughout the experimental period (d 7, 15, 21, 30 relative to birth). Different superscripts (a-b) indicate significant differences ($P < 0.05$) in the MI recorded in the LPS group. Different superscripts (A-D) indicate significant differences ($P < 0.05$) in the MI recorded in the CON group. Significant differences between both groups are represented with (*). IA = Intramammary administration. Data is expressed as LSM \pm SEM.

group on d 0 (20.1 ± 1.34 and 20.0 ± 1.25 mg/dL, respectively). However, no differences were observed between groups for the rest of the experimental period.

DISCUSSION

Several strategies have been investigated to improve the performance and health of calves, lambs, and goat kids. Most of these studies have focused on enhancing

colostrum and milk quality through nutritional management during gestation (Banchero et al., 2006; Celi et al., 2008; Gallo et al., 2020). However, the enrichment of colostrum and milk after parturition has also been tested. For instance, the inclusion of different molecules such as antibiotics (Yousif et al., 2018), hormones (Sanei et al., 2012), algae (Samarasinghe et al., 2021) and minerals (Kamada et al., 2007; Pourliotis et al., 2012) in colostrum and milk has reduced the incidence of diarrhea and enhanced the immune system development in calves. Despite this, the effect of colostrum obtained from an intramammary challenge with LPS on goat kid immune status, serum metabolites and performance have not been described before.

Udder inflammation triggers changes in the synthesis of components and alters the transfer of blood-derived molecules through the BMB (Bruckmaier & Wellnitz, 2017; Alcindo et al., 2023). As described by González-Cabrera et al. (2024), goats treated with an IA of LPS at parturition produced colostrum with higher IgG and IgM concentrations than those that received an IA without LPS. Similarly, Wellnitz et al. (2013) found that the IA of LPS to dairy cows can increase IgG₂ concentrations in milk (32 ± 8 and 173 ± 58 μ g/mL at 0 and 6 h after challenge, respectively). Currently, it is not feasible to determine the concentration of IgG subclasses (i.e., IgG₁ and IgG₂) in either goat colostrum, milk or blood as no quantitative methods are available. However, it is expected that the higher IgG concentration in colostrum from goats challenged with the IA of LPS was likely caused by an increased diffusion of IgG₂ through the leaky BMB or by a greater local synthesis and transfer of IgG₁ through transcytosis as reviewed by Hernández-Castellano et al. (2018) and Baumrucker et al. (2021).

Table 1. Plasma immunoglobulins (IgG and IgM) and serum metabolites concentrations, as well as rectal temperature, BW and individual milk intake on goat kids from the LPS (n = 15) and CON groups (n = 21)

Variables	Groups			Fixed effects		
	LPS	CON	SEM	IA	Time	IA \times T
RT, °C	39.1	39.2	0.05	0.555	<0.001	0.348
BW, kg	4.9	4.5	0.28	0.172	<0.001	0.187
MI, mL	1059.6	1166.4	80.20	0.231	<0.001	0.002
IgG, mg/mL	14.2	11.3	1.55	0.096	<0.001	0.977
IgM, μ g/mL	545.6	477.4		0.300	<0.001	0.409
	[330.8 – 899.9]	[295.3 – 771.7]				
Glucose, mg/dL	77.2	80.1	4.32	0.860	<0.001	0.206
Calcium, mg/dL	12.6	12.3	0.30	0.285	0.232	0.269
LDH, U/L	526.9	600.1	64.58	0.075	<0.001	0.824
TP, g/dL	5.1	4.8	0.18	0.099	<0.001	0.758
Albumin, g/dL	2.2	2.2	0.07	0.262	<0.001	0.549
Urea, mg/dL	12.1	12.3	1.04	0.844	<0.001	<0.001

LPS = goat kids from dams that received an IA with LPS (50 μ L of LPS in 2 mL of saline in each half udder); CON = goat kids from dams that received an IA without LPS (2 mL of saline in each half udder); IA = intramammary administration; IA \times T = Interaction IA \times Time; IgG = Immunoglobulin G; IgM = Immunoglobulin M; RT = Rectal temperature; MI = Individual milk intake; LDH = lactate dehydrogenase; TP = Total protein.

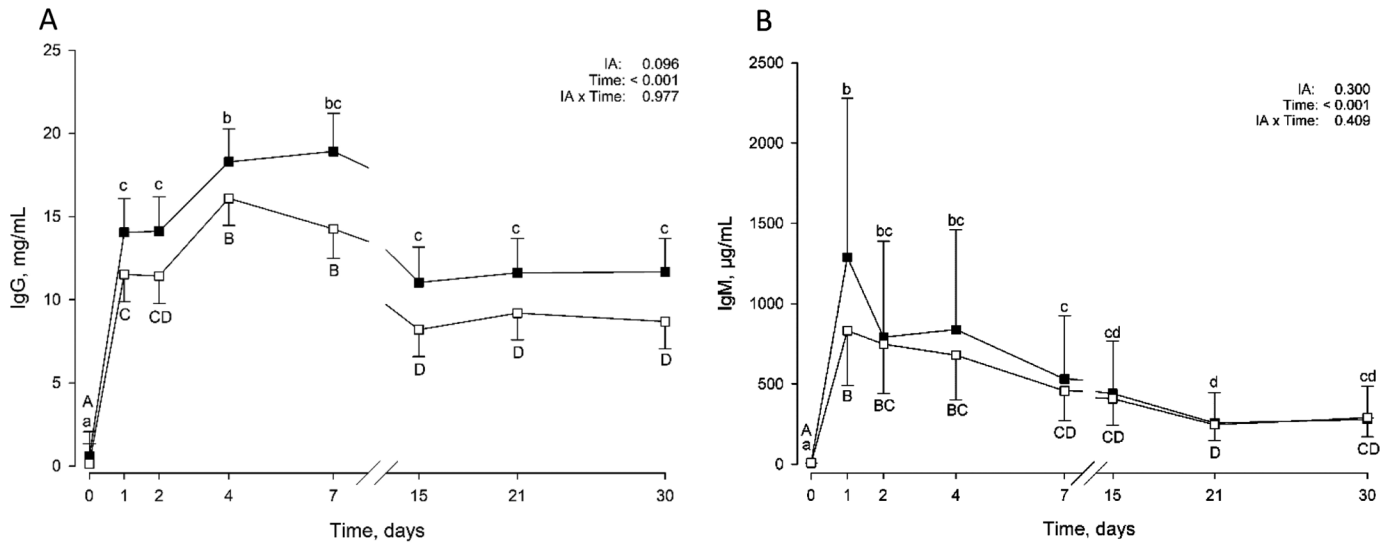


Figure 2. Plasma immunoglobulin G (IgG; A) and M (IgM; B) in the LPS (■) and CON (□) groups throughout the experimental period (d 0, 1, 2, 4, 7, 15, 21, 30 relative to birth). Different superscripts (a-d) indicate significant differences ($P < 0.05$) in the LPS group. Different superscripts (A-D) indicate significant differences ($P < 0.05$) in the CON group. Significant differences between both groups are represented with (*). IA = Intramammary administration. Data in Figure 2A is expressed as LSM \pm SEM. Data in Figure 2B is expressed as Mean [Minimum and Maximum].

Despite the present results showed no effects of the IA on plasma immunoglobulin concentrations, it would be also expected that goat kids receiving more immunoglobulin in colostrum would have higher IgG concentration in blood. This was previously described by Rodríguez et al. (2009) who assessed the effect of feeding newborn goat kids with colostrum containing different immunoglobu-

lin concentrations, finding that circulating IgG and IgM levels were higher in those animals receiving colostrum with the highest IgG and IgM concentrations (i.e., 80 mg/mL and 7.4 mg/mL, respectively). However, and despite some authors suggest the existence of an uptake selectivity among intestine segments, no receptors have been associated with the intestinal absorption of immunoglobulins (Staley and Bush, 1985; Ontsouka et al., 2016). This non-specific endocytosis of macromolecules might depend on the binding surface of the enterocyte membrane that can be saturated once exposed to colostrum. This could result in a limited capacity of absorption that might also explain the lack of differences in plasma IgG concentrations observed in this study. In addition, colostrum intake is essential to achieve a correct transfer of passive immunity (TPI), and its consumption should take place within the first hours of life (Argüello et al., 2004b) as enterocytes quickly lose the ability to absorb macromolecules in their native form (Stott et al., 1979; Moretti et al., 2013). Despite the 3 h delay in colostrum feeding, plasma IgG concentrations in goat kids were still above 10 mg/mL meaning there was no failure of TPI and agreeing with previous studies in which animals were fed colostrum immediately after birth (Argüello et al., 2004b; Rodríguez et al., 2009). In addition, litter size and goat kid sex did not influence plasma immunoglobulin concentration in the present study, as reported by previous literature in dairy goats (Argüello et al., 2004b, 2006).

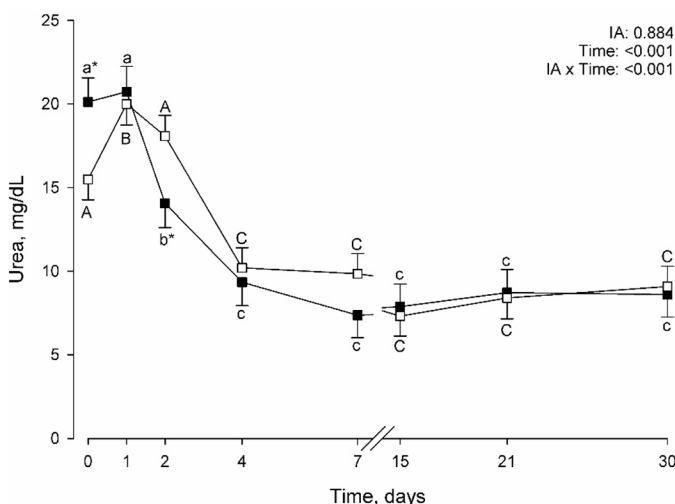


Figure 3. Urea concentration in the LPS (■) and CON (□) groups throughout the experimental period (d 0, 1, 2, 4, 7, 15, 21, 30 relative to birth). Different superscripts (a-c) indicate significant differences ($P < 0.05$) in the LPS group. Different superscripts (A-C) indicate significant differences ($P < 0.05$) in the CON group. Significant differences between both groups are represented with (*). IA = Intramammary administration. Data is expressed as LSM \pm SEM.

Despite the reduced MI recorded in goat kids from the LPS group on d 15, no differences on goat kid BW

were observed throughout the experimental period. Both groups grew evenly and constantly which indicates that the lower MI did not affect growth in the LPS group. These changes on MI could be associated to different individual consumptions patterns during the lactation period. Previous studies have demonstrated that animals under feed restriction can develop a compensatory gain weight once the normal intake is reestablished (Hornick et al., 2000; Costa et al., 2019). Therefore, it is likely that either the reduction of MI could not be enough to induce growth changes in goat kids from both groups or that the LPS group could experience a compensatory growth resulting in no differences on BW between both groups.

Although goat kid performance was not affected in this study, it has been demonstrated that feeding milk from cows suffering mastitis can increase the incidence of diarrhea in calves (Abb-Schwedler et al., 2014). This is probably associated with the oral acquisition of bacteria responsible for inducing inflammation and ultimately diarrhea. In the present study, the IA of LPS was performed aseptically and goat kids from the LPS group did not show diarrhea neither after colostrum consumption nor during the rest of the experimental period. The present findings suggest that colostrum obtained from goats that have been intramammary challenged with LPS has no detrimental effects on goat kid health. This might be explained by the low LPS concentration in colostrum as only 100 µg of LPS were infused in the udder (i.e., 50 µg of LPS diluted in 2mL in each half) and only a colostrum volume equivalent to 10% of birth BW was fed to each goat kid. This is supported by Samarasinghe et al. (2020) who observed no diarrhea or inflammatory reactions in dairy calves that were fed milk with greater amounts of LPS (i.e., 12 µg/kg BW) on d 34 of life. The effect of LPS on gastrointestinal health has been well described in adult and newborn ruminants (Guozhong et al., 2011; Araujo et al., 2013). Once the LPS is synthesized, it can translocate from the gut lumen to circulation and induce a systemic and local inflammation leading to a disruption of the intestinal barrier known as “open” or “leaky” gut (Sullivan et al., 2023). This higher intestinal permeability has been associated with periods of stress, high-starch diets or feed restriction in dairy cows (Kvidera et al., 2017; Fontoura et al., 2022). Yet, no studies have addressed the effects of oral LPS on gut permeability in newborn ruminants. Despite the assessment of oral LPS on goat kid health was not the aim of the present study, the lack of health issues could be likely associated with the action of salivary and gastric amylases as well as pancreatic lipases that may degrade the LPS before reaching the hind gut (Sissons, 1981).

In addition to performance variables, calcium, glucose, LDH, total protein, and albumin concentrations in serum did not differ between groups, agreeing with Alcindo et

al., (2016) who also found no changes on serum total protein neither in albumin, immunoglobulins, and acute-phase proteins (i.e., haptoglobin or transferrin) concentrations in goat kids that received colostrum from dams with subclinical mastitis. Despite previous studies have shown that milk chemical composition can be modified during udder inflammation (Hussain et al., 2012; Nogalska et al., 2020), changes in natural or experimentally induced mastitis may not be able to sufficiently impact colostrum composition and consequently lead to metabolic disruption and impairment of intestinal absorption of bioactive molecules. Although colostrum from the LPS group contained greater immunoglobulin concentrations, no effects in plasma immunoglobulins neither in serum albumin concentrations were observed, which can explain the lack of differences in total protein concentrations between both groups. In contrast, high urea concentrations were detected in the LPS group at birth. Increased levels of urea in blood can be associated with high protein diets and dehydration in cows, sheep, and goats (Giovanetti et al., 2019; Prah et al., 2022). Indeed, the dam nutritional status during the last weeks of gestation might also influence the circulating urea concentration in the offspring. In this study all dams received the same diet and had free access to water prepartum. Therefore, these differences in circulating urea concentrations at birth cannot be associated with the nutritional status of the dams. In addition, high urea concentrations during the first 24 h of life have been associated with high rates of amino acid oxidation after colostrum consumption (Greenwood et al., 2002). However, the difference in urea concentration between groups were observed at birth, thus there is no physiological explanation to justify these findings.

CONCLUSION

The present study demonstrated that feeding colostrum from goats challenged with an IA of LPS at parturition, containing higher IgG and IgM concentration, did not affect performance, the transfer of passive immunity and serum metabolites in newborn goat kids. Nevertheless, future studies need to address the effects of mastitis on colostrum composition and its consequences on metabolism and gastrointestinal absorption of bioactive components in neonates.

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DATA AVAILABILITY The data presented in this study are available on request from the corresponding author.

Abbreviations: BMB = Blood-milk barrier, IA = Intramammary administration, RT = Rectal temperature, MI = Individual milk intake, T = Time, TPI = Transfer of passive immunity, LDH = Lactate dehydrogenase

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