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Indian Society for Sheep and Goat Production and Utilization Conference

# Lead Papers



## Performance, Health and Welfare of Small Ruminants under Changing Climate Scenario

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Performance, Health and Welfare of Small Ruminants under  
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&

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## **Section II**

# **NOVEL APPROACHES IN SMALL RUMINANTS FEEDING AND NUTRITION**

**Section II: Novel Approaches in Small Ruminants Feeding and Nutrition****Chapter 4****UNLOCKING THE MYSTERIES OF COLOSTROGENESIS IN  
SMALL RUMINANTS: RECENT INSIGHTS AND  
DISCOVERIES**

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**Abstract**

Colostrum, the process by which mammals produce the initial mammary gland secretion before parturition, is a multifaceted and intricate phenomenon. Variations in colostrum composition have been widely observed, primarily attributed to differences in placental structure. In ruminants, the classical indicator of colostrum quality is IgG concentration, as immunoglobulin transfer from mother to foetus is absent. This manuscript delves into the latest advancements in understanding the physiology of colostrum production, with particular emphasis on the hypothesized role of FcRn. A novel concept explored here is the manipulation of the blood-milk barrier, with accompanying presentation of pertinent findings. Furthermore, factors such as litter size, number of lactations, and nutritional influences are thoroughly examined. The future of colostrum research hinges upon unravelling the mechanisms governing IgG transfer. Understanding this intricate process is essential for advancing our knowledge and optimizing colostrum-related outcomes.

**Physiology**

Colostrum, the process of colostrum formation in the mammary glands of mammals, commences prior to parturition. The transfer of immunoglobulins from the mother to the foetus is contingent upon the structure of the placenta in mammals (Castro et al., 2011b). Notably, in ruminants, this transfer is either absent or significantly diminished, resulting in new-born that are either agammaglobulinemic or exhibit markedly low serum immunoglobulin concentrations (Agradi et al., 2023). Additionally, the neonatal period in ruminants presents a narrow window for immunoglobulin absorption, typically spanning around two days (Castro-Alonso et al., 2008). These inherent characteristics underscore the critical importance of timely colostrum ingestion in the management of neonatal ruminants.

Colostrum is renowned for its richness in immunoglobulins, immune-related factors, minor proteins, and energy (Hernandez-Castellano et al., 2015a). Despite this, our understanding of its formation remains incomplete. Recently, Baumrucker and colleagues (Baumrucker et al., 2021) proposed a novel hypothesis elucidating the role of FcRn in the transfer of IgG1 from blood serum to colostrum.

Their findings align with earlier observations by Dr. Ciupercescu in 1977 (Ciupercescu, 1977), who noted a 40% decrease in IgG1 serum concentration during the final 15 days prior to parturition in sheep. This underscores the dynamic nature of colostrum formation and the intricate mechanisms involved in immunoglobulin transfer. For a comprehensive understanding of the endocrinological aspects

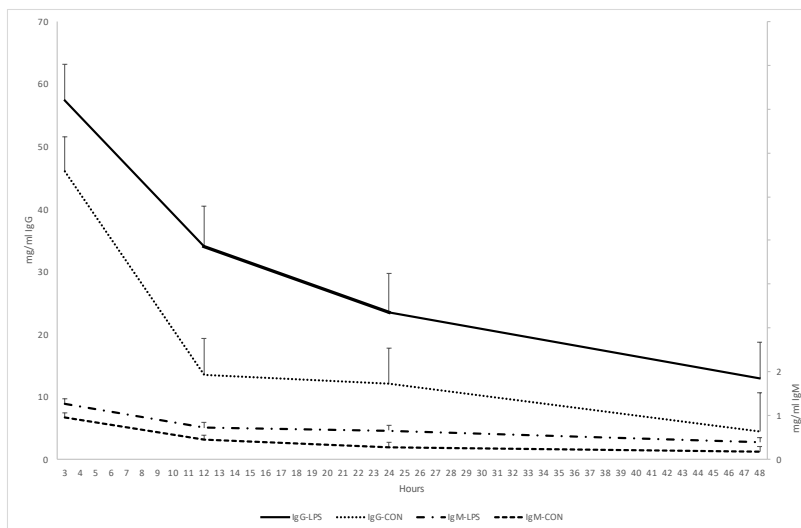
related to colostrum formation, we recommend reviewing the work of Dr. Bruckmaier's group (Bigler et al., 2023). Their review delves into the multifaceted interplay of hormonal regulation in the context of colostrum synthesis, shedding light on the complex processes underlying this crucial aspect of mammalian lactation.

### Using the blood milk barrier

Within the mammary gland, a crucial function is performed by the blood-milk barrier, which regulates the selective exchange of substances between the bloodstream and milk. While colostrum production primarily relies on active processes like endocytosis or transcytosis, certain immune components, such as IgG, can also traverse into colostrum through compromised tight junctions (Baumrucker and Bruckmaier, 2014). Mastitis, an inflammation of the mammary gland, disrupts these tight junctions between epithelial cells, thereby compromising the integrity of the blood-milk barrier and facilitating the passage of plasma proteins, antibodies, leukocytes, and other constituents from the blood into the milk (Bruckmaier and Wellnitz, 2017). Manipulating the integrity of the blood-milk barrier serves as a

valuable tool for studying the udder's inflammatory response under various challenges (Wall et al., 2018). In dairy cows, the intramammary administration of oxytocin (Wall et al., 2016), progesterone (Nguyen and Neville, 1998), and certain nonsteroidal anti-inflammatory drugs, such as selective and non-selective cyclooxygenase inhibitors (Sintes et al., 2020), compromises the integrity of the blood-milk barrier, while prolactin (Flint and Gardner, 1994) and glucocorticoids like cortisol (Herve et al., 2017) or prednisolone (Wellnitz et al., 2014) stabilize it, preventing leakage. Our lab hypothesized that the use of lipopolysaccharides (LPS), found in the cell walls of Gram-negative bacteria, and playing a crucial role in host-pathogen interactions with the innate immune system could induce a sterile form of mastitis and indirectly alter the composition of colostrum and milk (González-Cabrera et al., 2022; Gonzalez-Cabrera et al., 2024).

In Figure 1, the IgG and IgM colostrum concentrations obtained by Gonzalez-Cabrera et al. (2024) are shown, illustrating a clear increase in the concentration of IgG and IgM in animals treated with LPS.



**Figure 1. IgG and IgM colostrum concentration after partum in control (con) and LPS (LPS) animals.**

### Litter size and lactation number

Recent research (Zhou et al., 2023) and earlier scientific studies (Arguello et al., 2006) do not align on the effect of litter size and the number of lactations on IgG colostrum concentration. However, they concur that the effect is minimal and only noticeable during the initial milking.

### Nutrition

Recent studies (Nouri et al., 2023) have demonstrated that both prepartum and postpartum feed restriction in fat-tailed dairy sheep did not significantly affect colostrum IgG concentration, and consequently, there was no discernible impact on IgG concentrations in the bloodstream of new born lambs. However, classical studies (Banchemo et al., 2004) have shown that supplementing female sheep with a high-energy feed during the final week of pregnancy can enhance colostrum production.

Both sets of findings are not contradictory, as demonstrated by the experiments conducted by (Hare, 2023) which serve as a good example to elucidate this controversy. Hare (2023) fed cattle with rations that varied in energy content: deficient (92% of the metabolizable energy (ME) requirement), adequate (104% of the ME requirement), or excess (118% of the ME requirement) for 53 days prior to calving. It was observed that increasing energy levels led to a reduction in colostrum IgG concentration, decreasing from 168 to 137 mg/ml (for deficient and excess energy levels, respectively). However, this increase in energy also resulted in an augmentation in both the volume of colostrum produced, rising from 1.5 to 2.6 kg (for deficient and excess energy levels, respectively), and the total mass of IgG produced, increasing from 221 to 370 g (for deficient and excess energy levels, respectively).

These findings suggest that modulating nutrition can indeed enhance the mass of colostrum produced. Nevertheless, the transfer of IgG from

blood to colostrum remains challenging to modulate.

### Conclusions and future perspectives

There are several factors that influence colostrogenesis, some of which have been addressed in the present manuscript. However, a wealth of additional information is available in the literature. Variations in both colostrum quantity and quality have been observed among different breeds of small ruminants, indicating a genetic influence on colostrum composition (Hernandez-Castellano et al., 2015b). Immunization of pregnant ewes or does can have a positive impact on colostrum quality by increasing specific antibody levels (Lewis et al., 2017). Furthermore, factors such as handling stress, environmental conditions, and timing of colostrum harvesting can significantly affect colostrum quality (Castro et al., 2011b). Additionally, colostrum quality may vary depending on the stage of gestation at which it is harvested, with colostrum collected closer to parturition typically exhibiting higher IgG concentrations (Castro et al., 2011a). Moreover, environmental factors such as temperature and humidity have been shown to impact colostrum composition and quality (Todaro et al., 2023).

Looking ahead, it is crucial to elucidate the IgG transfer mechanism in the mammary gland in order to enhance both the quality and quantity of colostrum in the future. Understanding this mechanism is paramount for comprehending this phenomenon and improving colostrum-related outcomes.

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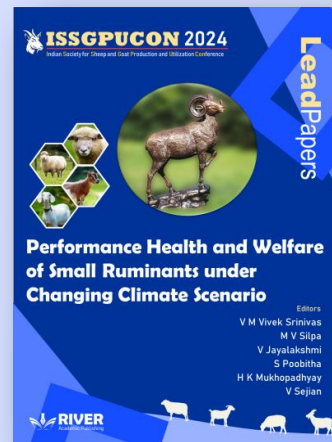


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## Performance, Health and Welfare of Small Ruminants under Changing Climate Scenario

### ISSGPUCON 2024 | Lead Papers Book

Among the livestock species, small ruminants play a vital role in contributing towards Indian economy and provides livelihood to nearly two-third of the rural community. Sheep and goat farming supports the agrarian economy especially in areas where crop and dairy farming are not economical. Furthermore, in the current global climate change scenario with the alarmingly rising human population and urbanization, small ruminant farming may play a significant role in ensuring economic security to the poor and marginal farmers. Having said so, farming and research developments in small ruminant farming is relatively lesser when compared to other livestock species like cattle.



This book thereby is a compilation of the vital concepts and some of the recent advancements and innovations in the field of sheep and goat production. This volume can serve as a preamble for students, lecturers, researchers, scientists and policy makers in India and across the globe. This volume consists of chapters authored by eminent researchers from India and across the world having vast experience in small ruminants. The volume is an exemplary compilation of 34 chapters which can be broadly categorized into 11 sections. Most importantly the book covers areas on climate resilient small ruminant production, novel approaches in small ruminants feeding and nutrition. The book also focusses on the clinical advancements like recent trends in reproductive management, contemporary diagnostic techniques in small ruminants, advances in small ruminant therapeutics and ethno veterinary practices. Particular emphasis was also given to cover the area on omics approaches for re-defining breeding strategies in small ruminants, innovations in sustainable sheep and goat production and prospects for value addition in small ruminant products. Lastly, this volume also provides detailed description of newer perspectives in sheep and goat welfare. Overall this volume would be of great interest to varied policy makers as it contains sections on role of small ruminants in socio-economic upliftment and policies and marketing strategies for small ruminant sector. Thus, this book can be a vital source of reference for all stakeholders on livestock farming system, consisting updated information in varied aspects of small ruminant production.

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