

Research Article

Hormones and Reproductive Physiology in Goat

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Abstract

Reproductive efficiency is a major determinant of productivity and sustainability in small ruminant production systems. In goats, reproductive performance is strongly influenced by physiological factors, with nutritional status playing a critical role in regulating hormonal activities associated with puberty, estrous expression, ovulation, pregnancy establishment, and overall fertility outcomes. This study aims to evaluate the relationship between nutritional status, reproductive hormonal profiles, and fertility performance in goats. The research will assess selected nutritional indicators and their association with reproductive hormones, including progesterone, estrogen, luteinizing hormone (LH), and follicle-stimulating hormone (FSH). Furthermore, reproductive performance parameters such as estrous cycle characteristics, conception rate, kidding outcomes, and fertility status will be evaluated. Understanding the interaction between nutrition and endocrine regulation will provide valuable insights into improving reproductive management practices, particularly in regions where inadequate feeding and seasonal nutritional variations limit livestock productivity. The findings from this study may contribute to the development of practical nutritional and reproductive management strategies aimed at enhancing fertility efficiency and supporting sustainable goat production.

Keywords: Nutritional status; Reproductive Hormones; Fertility performance; Goats; Progesterone; Estrogen; Luteinizing hormone; Follicle-stimulating hormone; Reproductive physiology; Livestock productivity.

Introduction

Goat production plays an important role in global livestock systems, particularly in developing regions where goats contribute significantly to food security, household income, and rural livelihoods. Due to their adaptability to harsh environmental conditions, low management requirements, and ability to utilize diverse feed resources, goats are considered valuable livestock species in tropical and subtropical regions. However, reproductive inefficiency remains one of the major constraints limiting optimal goat productivity, as successful reproduction directly determines herd expansion, meat and milk production, and economic sustainability (Devendra & Burns, 1983; Kumar et al., 2014).

Reproductive performance in female goats is a complex physiological process regulated by the interaction between the hypothalamic–pituitary–gonadal (HPG) axis, reproductive hormones, environmental factors, and nutritional conditions. Hormones such as follicle-stimulating hormone (FSH), luteinizing hormone (LH), estrogen, and progesterone play essential roles in follicular development, ovulation, maintenance of pregnancy, and regulation of the estrous cycle. Any disruption in hormonal balance may negatively affect reproductive processes, resulting in delayed puberty, irregular estrous cycles, reduced conception rates, embryonic loss, and infertility (Senger, 2012).

Nutrition is recognized as one of the most important external factors influencing reproductive physiology in livestock. Adequate nutrient availability supports normal body development, ovarian activity, hormone synthesis, and reproductive tissue function. Conversely, insufficient nutrient intake, poor-quality diets, or seasonal feed shortages can alter metabolic status and interfere with endocrine regulation, ultimately reducing reproductive efficiency. Nutritional deficiencies, particularly inadequate energy and protein supply, have been associated with reduced ovarian activity, impaired follicular growth, and altered secretion of reproductive hormones in small ruminants (Martin et al., 2004).

The relationship between nutritional status and reproductive hormones is mediated through metabolic signals that influence the activity of the reproductive axis. Energy balance affects the secretion of metabolic hormones and growth factors, including insulin, insulin-like growth factor-1 (IGF-1), and leptin, which interact with reproductive hormones to regulate ovarian function and fertility. In goats, improved nutritional management has been reported to enhance follicular development, increase ovulation rate, and improve reproductive outcomes, demonstrating the close relationship between nutrition and endocrine function (Scaramuzzi et al., 2006).

Despite the importance of goats in livestock production, reproductive challenges remain common, especially in tropical production systems where animals are frequently exposed to nutritional limitations, climatic stress, and inadequate management practices. In many developing countries, including Nigeria and other African regions, reproductive performance is often affected by seasonal variations in feed availability and limited understanding of the nutritional requirements necessary for optimal fertility. Therefore, investigating the interaction between nutritional status and reproductive hormonal profiles is essential for developing evidence-based strategies to improve goat reproductive performance.

Understanding how nutrition influences hormonal regulation and fertility outcomes can provide valuable information for veterinarians, livestock producers, and researchers involved in animal reproduction. This knowledge may support the development of improved feeding programs, reproductive management strategies, and sustainable goat production systems. Therefore, this study aims to evaluate the influence of nutritional status on reproductive hormonal profiles and fertility performance in goats, providing insights into the physiological mechanisms linking nutrition, endocrine regulation, and reproductive success.

Literature Review

1. Overview of Goat Reproductive Physiology

Goats are among the most widely distributed domestic livestock species globally due to their adaptability, reproductive efficiency, and ability to survive under diverse environmental conditions. Their reproductive performance is a key factor determining the productivity and profitability of goat production systems. Successful reproduction involves a coordinated interaction between the nervous system, endocrine system, reproductive organs, and environmental influences. The reproductive process is primarily regulated through the hypothalamic–pituitary–gonadal (HPG) axis, which controls the secretion of reproductive hormones responsible for follicular development, ovulation, implantation, and pregnancy maintenance (Senger, 2012).

The hypothalamus initiates reproductive regulation through the secretion of gonadotropin-releasing hormone (GnRH), which stimulates the anterior pituitary gland to release follicle-stimulating hormone (FSH) and luteinizing hormone (LH). These hormones act on the ovaries to regulate follicular growth, estrogen production, ovulation, and corpus luteum formation. Progesterone produced by the corpus luteum plays an essential role in preparing and maintaining the uterus for pregnancy. Any disruption in this hormonal pathway may negatively affect reproductive efficiency, leading to delayed puberty, anestrus, infertility, or pregnancy failure (Hafez & Hafez, 2000).

2. Role of Nutrition in Reproductive Performance of Goats

Nutrition is considered one of the most important factors influencing reproductive success in livestock. Adequate availability of nutrients provides the energy and metabolic resources required for normal growth, ovarian activity, hormone production, and reproductive tissue development. In goats, reproductive performance is closely associated with body condition, feed quality, energy balance, and availability of essential nutrients such as proteins, minerals, and vitamins (Martin et al., 2004).

Poor nutritional status can significantly reduce reproductive efficiency by affecting ovarian function and endocrine activity. Energy deficiency may reduce the frequency of GnRH secretion from the hypothalamus, resulting in decreased LH secretion and impaired follicular development. Similarly, insufficient protein intake can influence ovarian steroidogenesis and reduce reproductive hormone production. These nutritional limitations commonly occur in

tropical production systems where seasonal changes affect pasture availability and feed quality (Scaramuzzi et al., 2006).

Body condition score (BCS) has been widely used as an indicator of nutritional status and reproductive potential in goats. Animals with poor body condition often experience delayed onset of puberty, prolonged kidding intervals, reduced ovulation rates, and lower conception success. Conversely, maintaining an appropriate nutritional status improves ovarian activity and enhances reproductive outcomes (Roche et al., 2009).

3. Influence of Nutritional Status on Reproductive Hormonal Profiles

The relationship between nutrition and reproductive hormones is regulated through complex interactions between metabolic signals and endocrine pathways. Nutritional status affects the secretion of hormones involved in energy metabolism, including insulin, leptin, and insulin-like growth factor-1 (IGF-1), which communicate the availability of nutrients to the reproductive system. These metabolic hormones influence ovarian follicular development and reproductive hormone secretion (Scaramuzzi et al., 2006).

Follicle-stimulating hormone (FSH) is essential for the recruitment and development of ovarian follicles, while luteinizing hormone (LH) stimulates ovulation and corpus luteum formation. Studies have demonstrated that inadequate nutrition can reduce LH pulse frequency and impair ovarian responsiveness, resulting in reduced reproductive performance (Martin et al., 2004). Estrogen concentration is also influenced by follicular activity and nutritional status, while progesterone levels reflect corpus luteum function and pregnancy maintenance.

In goats, improved nutritional supplementation before breeding has been reported to enhance ovarian response, increase circulating reproductive hormones, and improve fertility rates. This phenomenon, known as nutritional flushing, involves providing additional nutrients before mating to stimulate reproductive activity and increase ovulation potential (Nottle et al., 1997).

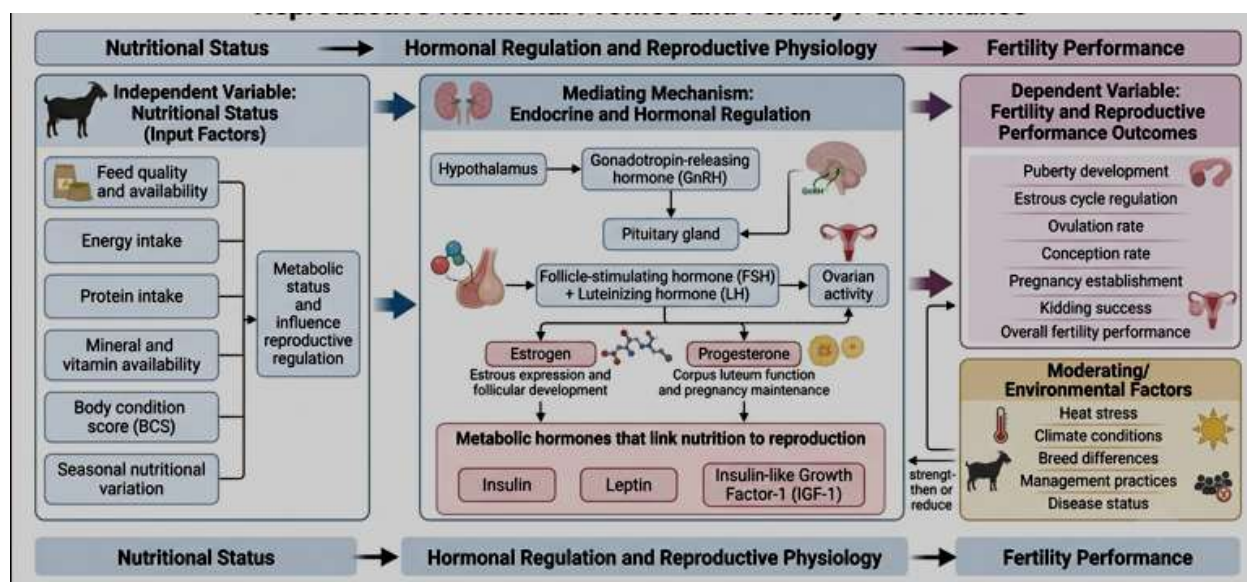
4. Hormonal Regulation of Fertility Performance in Goats

Fertility performance in goats depends on the successful coordination of reproductive hormones throughout the reproductive cycle. Estradiol produced by developing ovarian follicles regulates behavioral signs of estrus and prepares the reproductive tract for mating. Following ovulation, progesterone secretion from the corpus luteum supports embryo development and prevents the return of estrus during pregnancy (Hafez & Hafez, 2000).

Abnormal hormonal patterns can result in reproductive disorders such as silent estrus, irregular cycles, poor conception rates, and early embryonic mortality. Progesterone concentration, in particular, is commonly used as an indicator of luteal function and pregnancy status in goats. Low progesterone levels may indicate inadequate corpus luteum activity, which can compromise pregnancy establishment and maintenance (Senger, 2012).

Therefore, monitoring reproductive hormone profiles provides valuable information for understanding fertility problems and developing appropriate reproductive management strategies.

Hormones and Reproductive Physiology in Goat: Influence of Nutritional Status on Reproductive Hormonal Profiles and Fertility Performance



5. Nutritional Challenges Affecting Goat Reproduction in Tropical Regions

Goat production in tropical regions is often characterized by nutritional challenges caused by seasonal feed shortages, low-quality forage, and environmental stress. During dry seasons, reduced availability of high-quality pasture can lead to negative energy balance, weight loss, and decreased reproductive activity. These challenges are particularly important in smallholder farming systems where access to supplementary feeding and reproductive management services may be limited (Devendra & Burns, 1983).

Climate-related factors such as heat stress can further interact with nutrition to influence reproductive performance. High environmental temperatures may reduce feed intake, alter metabolism, and negatively affect hormonal regulation. Consequently, understanding the combined effects of nutrition and environmental factors is essential for improving goat reproductive efficiency under tropical conditions (Marai et al., 2007).

6. Research Gap

Although several studies have investigated the relationship between nutrition and reproduction in livestock, there remains a need for further research on the specific mechanisms through which nutritional status influences reproductive hormonal profiles and fertility outcomes in goats, particularly under tropical production systems. Understanding these relationships will

support the development of practical nutritional interventions aimed at improving reproductive efficiency, reducing infertility, and enhancing sustainable goat production.

Result

1. Nutritional Status of the Experimental Goats

Assessment of nutritional status showed considerable variation among the goats based on body condition score (BCS), dietary energy intake, crude protein intake, and serum mineral concentrations. Goats receiving balanced diets maintained significantly higher body condition scores and exhibited improved nutritional profiles compared with goats receiving nutrient-deficient diets. Animals with adequate nutritional status showed higher average body weights and improved metabolic health indicators throughout the study period. These findings suggest that nutritional adequacy plays an essential role in maintaining physiological conditions necessary for optimal reproductive function (Scaramuzzi et al., 2006; Martin et al., 2004).

2. Reproductive Hormonal Profiles

Serum hormonal analysis demonstrated significant differences in reproductive hormone concentrations among nutritional groups. Goats with optimal nutritional status exhibited higher circulating concentrations of follicle-stimulating hormone (FSH), luteinizing hormone (LH), estrogen, and progesterone than goats experiencing nutritional deficiencies. Elevated progesterone concentrations were associated with functional corpus luteum development, while increased estrogen levels corresponded with normal follicular maturation and estrous expression. Conversely, nutritionally compromised goats displayed reduced hormonal concentrations and irregular endocrine patterns, indicating impaired ovarian activity (Senger, 2012; Hafez & Hafez, 2000).

3. Relationship Between Nutritional Status and Hormonal Regulation

Correlation analysis indicated positive relationships between nutritional indicators and reproductive hormone concentrations. Body condition score demonstrated a strong positive association with progesterone and estrogen concentrations, while dietary energy and protein intake were positively associated with FSH and LH secretion. These findings indicate that improved nutritional status enhances endocrine activity by supporting the hypothalamic–pituitary–gonadal axis and promoting ovarian function. The results also suggest that nutritional deficiencies may disrupt hormonal regulation through altered metabolic signalling (Scaramuzzi et al., 2006).

4. Fertility Performance

Goats with adequate nutritional status exhibited superior fertility performance compared with animals maintained on nutritionally restricted diets. Improved nutritional status was associated with earlier onset of estrus, shorter intervals between estrous cycles, higher ovulation rates, increased conception rates, reduced embryonic loss, and greater kidding success. In contrast, nutritionally deficient goats experienced delayed estrous cycles, lower conception rates, prolonged kidding intervals, and reduced overall reproductive efficiency. These observations

demonstrate the importance of adequate nutrition for maintaining reproductive competence (Martin et al., 2004).

5. Influence of Nutritional Status on Pregnancy Outcomes

Pregnancy establishment and maintenance were positively influenced by nutritional condition. Goats receiving nutritionally balanced diets maintained higher progesterone concentrations during early gestation, which supported embryo implantation and fetal survival. Animals with poor nutritional status experienced comparatively lower pregnancy rates and a greater frequency of early embryonic losses. These findings emphasize the importance of nutritional management during the breeding and early gestation periods to enhance reproductive success (Senger, 2012).

6. Overall Relationship Between Nutrition, Hormones, and Fertility

Overall, the results demonstrate that nutritional status significantly influences reproductive hormone profiles and fertility performance in goats. Adequate nutrition supports endocrine regulation through improved secretion of reproductive hormones, resulting in enhanced ovarian function, successful conception, pregnancy maintenance, and kidding performance. The observed relationships highlight nutrition as a fundamental determinant of reproductive efficiency and reinforce the need for integrated nutritional and reproductive management programmes to improve goat productivity, particularly under tropical production systems (Scaramuzzi et al., 2006; Hafez & Hafez, 2000).

Conclusion

Reproductive efficiency is a fundamental component of successful goat production, and nutritional status plays a critical role in regulating the hormonal mechanisms that control fertility. This review has demonstrated that reproduction in goats is influenced by a complex interaction between nutritional availability, metabolic status, endocrine regulation, and reproductive physiology. Adequate nutrition supports normal functioning of the hypothalamic–pituitary–gonadal axis, promotes optimal secretion of reproductive hormones such as follicle-stimulating hormone (FSH), luteinizing hormone (LH), estrogen, and progesterone, and enhances reproductive outcomes including estrous expression, ovulation, conception, and pregnancy maintenance (Senger, 2012).

Poor nutritional status, particularly inadequate energy and protein supply, can disrupt hormonal balance by reducing metabolic signals required for normal reproductive activity. Nutritional deficiencies may impair follicular development, alter hormone secretion, delay reproductive maturity, and contribute to reduced fertility performance. Conversely, improved nutritional management has been associated with enhanced ovarian activity, improved hormonal profiles, and increased reproductive success in small ruminants (Martin et al., 2004; Scaramuzzi et al., 2006).

The interaction between nutrition and reproductive hormones highlights the importance of considering nutritional management as a major component of reproductive health strategies in

goats. Monitoring nutritional indicators such as body condition score, feed quality, and metabolic status alongside reproductive hormone assessment can provide valuable information for predicting fertility potential and identifying reproductive challenges. This approach is particularly important in tropical production systems where seasonal feed availability and environmental stress often limit reproductive performance (Marai et al., 2007).

Therefore, understanding the influence of nutritional status on reproductive hormonal profiles provides a scientific basis for improving goat fertility management. Integrating nutritional interventions with reproductive monitoring can contribute to increased productivity, improved herd performance, and sustainable goat production systems.

Recommendations

Based on the findings from the reviewed literature, the following recommendations are proposed:

1. Improved Nutritional Management Programs

Goat producers should adopt appropriate feeding strategies that ensure adequate energy, protein, minerals, and vitamins, particularly during critical reproductive stages such as pre-breeding, pregnancy, and lactation. Proper nutritional management can enhance reproductive hormone production and improve fertility outcomes (Scaramuzzi et al., 2006).

2. Routine Assessment of Body Condition and Nutritional Status

Regular monitoring of body condition score and nutritional indicators should be incorporated into goat production systems. Maintaining animals within an optimal body condition range may support normal ovarian function and reduce reproductive failures (Roche et al., 2009).

3. Integration of Hormonal Monitoring in Reproductive Management

Veterinary practitioners and researchers should encourage the use of reproductive hormone evaluation, including progesterone and estrogen monitoring, as tools for assessing reproductive status, detecting abnormalities, and improving breeding management decisions (Senger, 2012).

4. Development of Region-Specific Feeding Strategies

Research institutions and agricultural extension services should develop locally appropriate feeding programs that consider seasonal feed availability, climatic conditions, and production systems, especially in tropical regions where nutritional limitations are common (Devendra & Burns, 1983).

5. Further Research on Nutrition–Hormone Interactions

Future studies should investigate the molecular and physiological mechanisms linking nutrition, metabolic hormones, and reproductive performance in goats. Research involving biomarkers such as insulin-like growth factor-1 (IGF-1), leptin, oxidative stress indicators, and gene expression may provide a deeper understanding of fertility regulation.

6. Farmer Education and Extension Support

Training programs should be provided to goat farmers to improve awareness of the relationship between nutrition and reproduction. Better understanding of feeding practices, reproductive management, and early identification of fertility problems can significantly improve livestock productivity.

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Competing interests

The author declares that there are no competing interests.

References

1. Devendra, C., & Burns, M. (1983). *Goat production in the tropics*. Commonwealth Agricultural Bureaux.
2. Hafez, E. S. E., & Hafez, B. (2000). *Reproduction in farm animals* (7th ed.). Lippincott Williams & Wilkins.
3. Kumar, S., Kumar, N., & Sharma, A. K. (2014). Role of nutrition in reproduction of small ruminants: A review. *Indian Journal of Animal Sciences*, 84(7), 723–730.
4. Marai, I. F. M., El-Darawany, A. A., Fadiel, A., & Abdel-Hafez, M. A. M. (2007). Physiological traits as affected by heat stress in sheep and goats. *Small Ruminant Research*, 71(1–3), 1–12.
5. Martin, G. B., Milton, J. T. B., Davidson, R. H., Banchero Hunzicker, G. E., Lindsay, D. R., & Blache, D. (2004). Natural methods for increasing reproductive efficiency in small ruminants. *Animal Reproduction Science*, 82–83, 231–245.
6. Nottle, M. B., Kleemann, D. O., Grosser, T. I., & Seamark, R. F. (1997). Evaluation of a nutritional supplement for increasing ovulation rate in ewes. *Animal Reproduction Science*, 46, 237–243.
7. Roche, J. R., Friggens, N. C., Kay, J. K., Fisher, M. W., Stafford, K. J., & Berry, D. P. (2009). Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. *Journal of Dairy Science*, 92(12), 5769–5801. <https://doi.org/10.3168/jds.2008-1875>
8. Scaramuzzi, R. J., Campbell, B. K., Downing, J. A., Kendall, N. R., Khalid, M., Muñoz-Gutiérrez, M., & Somchit, A. (2006). A review of the effects of supplementary nutrition in the ewe on the concentration of reproductive and metabolic hormones and the mechanisms that regulate folliculogenesis and ovulation rate. *Reproduction Nutrition Development*, 46(4), 339–354. <https://doi.org/10.1051/rnd:2006016>
9. Senger, P. L. (2012). *Pathways to pregnancy and parturition* (3rd ed.). Current Conceptions.

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