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A Physiological Perspective on Lactation in Goats

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Abstract: The domesticated species of goats, scientifically known as *Capra hircus*, have played a significant role in several aspects of human existence over the course of history. These animals have made notable contributions to both individual animal breeding practices and the overall national economy. Their unique meat and milk production, along with their ease of cultivation, distinguish them as noteworthy entities. Goat milk is widely favored by customers due to its hypoallergenic features, low lactose levels, and rich composition. As a result, goat breeding has been prevalent in our country and globally for milk production in animal husbandry. In accordance with the purpose of achieving a high-quality final product, which constitutes a primary goal of animal husbandry, it is important to possess knowledge on certain attributes relating to the animal under cultivation. The aforementioned characteristics pertain to the anatomical composition of the udder and the physiological processes involved in lactation in goats. Lactation is a complex process consisting of three phases in total, including a number of morphological and endocrinological changes, which can be affected by factors such as time of birth, number of litters, and ration. Lactation process consists of mammogenesis, which includes morphological changes that make the mammary gland suitable for the lactation period, lactogenesis, which includes the secretion of milk, and galactopoiesis, which ensures the continuity of lactation. The average lactation period in goats is 210-280 days, the highest milk yield in lactation is formed between the 35-60th days and the highest lactation milk yield is observed following the 3-4th birth. In this review, the structure and development of the udder in goats, the components of lactation physiology, the initiation and maintenance of lactation and the factors affecting the ongoing lactation will be discussed.

Keywords: Galactopoiesis, Goat, Goat Milk, Lactation Physiology, Mammogenesis

Keçilerde Laktasyona Fizyolojik Bir Bakış

Özet: İnsanlık tarihi boyunca hayatımızın birçok noktasına katkıda bulunmuş gerek bireysel hayvan yetiştiriciliği gerekse ülke ekonomisine katkı sağlaması hususundan pek fazla etkisi bulunan keçiler (*Capra hircus*), et ve süt verimleriyle ve kolay yetiştirilebilir olması açısından ön plana çıkmaktadır. Özellikle hipoalerjneik özellikleri, düşük laktoz düzeyleri ve zengin içerik kompozisyonu ile tüketiciler arasında sıklıkla tercih edilen keçi sütü ülkemiz ve global hayvan yetiştiriciliğinde süt üretimi açısından keçi yetiştiriciliğini yaygınlaştırmıştır. Hayvan yetiştiriciliğinin ana hedeflerinden biri olan kaliteli son ürün elde etme gayesi doğrultusunda ise yetiştirilen hayvanın birtakım özelliklerinin bilinmesini önem arz etmektedir. Bu özellikler söz konusu durumda keçilerde memenin yapısı ve laktasyon fizyolojisidir. Laktasyon toplamda üç fazdan oluşan, bir takım morfolojik ve endokrinolojik değişimleri bünyesinde barındıran, doğum zamanı, yavrulama sayısı, rasyon gibi faktörlerden etkilenebilen kompleks bir süreçtir. Bu süreç ise meme bezinin laktasyon periyodu için elverişli hale gelebilmesini kapsayan morfolojik değişimleri içerin mammogenezisi, süt salgısının oluşturulmasını kapsayan laktogenezi ve laktasyonun devamlılığını sağlayan galaktopoezden oluşmaktadır. Keçilerde ortalama laktasyon periyodu 210-280 gün olup, laktasyonda en yüksek süt verimi 35-60. günler arasında şekillenmekte ve en yüksek laktasyon süt verimi 3-4. doğumu takiben gözlemlenmektedir. Bu derlemede ise keçilerde memenin yapısı ve gelişimi, laktasyon fizyolojisinin bileşenleri olan laktasyonun başlaması ve devamlılığının sağlanması ve devam eden laktasyona etkili olan faktörler ele alınacaktır.

Anahtar Kelimeler: Galaktopoez, Keçi, Keçi Sütü, Laktasyon Fizyolojisi, Mammogenez

1. Giriş

Goats, which are thought to be the first domesticated animal in the Mesopotamia region about 10,000 years ago, caused various effects on the lives of people in the Sumerians, one of the first civilizations of this region, in many different aspects. Today, this impact is considered from the perspective of milk production, especially in the Middle East region, where goats are an important component of the agricultural system and contribute to the national economy of the country (1-3). In recent years, there has been a growing recognition of the significance of dairy goats, both domestically and internationally, owing to the escalating global demand for goat milk products intended for human use. The dairy goat sector has experienced significant growth, with worldwide goat farming exhibiting exponential expansion in the past decade, surpassing that of sheep and cattle. Goat milk accounts for 2.3% of the overall worldwide milk output, which is comparatively greater than the proportion attributed

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to sheep milk, standing at 1.3%. Small ruminants, such as goats, possess several benefits in comparison to bigger cattle. Several advantages of keeping goats include their cost-effectiveness, their ability to utilize domestic waste resources, their lower feed and water requirements, and their overall lack of need for specialized housing. (4). Mahatma Gandhi himself referred to these animals as "The Poor Man's Cow " due to the aforementioned attributes. (5).

When selecting a goat breed, individuals consider factors such as desired yield characteristics and the breed's compatibility with the local geographical conditions, given the vast array of goat breeds available worldwide (6). When considering the classification of goat breeds, particularly in relation to yield, an important criterion in breeding, they can be classified as "Dairy Breeds, Meat Breeds, Fiber Type Breeds, Combined Yield Breeds, and finally, Fur and Combined Breeds." (7). The categorization of goats according to their productivity is determined by their breed type. Dairy breeds such as Saanen, Toggenburg, Malta, Damascus, White German, Nubi, and Kilis are classified based on their milk output (8). The breeds that are extensively raised in our nation include the hair goat, Ankara Angora goat, Kilis goat, Saanen, German Pied Noble Goat, Toggenburg, German White Noble, and Damascus (Aleppo) goat. (7, 8). Within this group of breeds, the Hair goat has an average lactation milk output ranging from 121 to 134 kg. The duration of the lactation period for this breed spans between 212 and 213 days, while the average daily milk yield during lactation falls within the range of 0.57 to 0.62 kg. The Kilis goat has an average lactation milk output ranging from 204 to 247 kg, with an average lactation length spanning from 196 to 231 days. Furthermore, the average daily milk yield during lactation is seen to be within the range of 0.88 to 1.27 kg. (9, 10). Certain goats have the capacity to provide milk exceeding 2,000 kg throughout a single lactation period. Goat breeds with high milk production potential have the capacity to generate around 10 kg of milk each day throughout the lactation period (2).

The average composition of goat milk states that it includes 13.2% total dry matter, including 4.5% fat, 3.6% protein, 4.3% lactose, and 0.8% minerals. In comparison to cow and human milk, goat milk exhibits somewhat higher levels of total dry matter, fat, total protein, casein, and minerals, while displaying lower levels of lactose. (11, 12). Goat milk has elevated concentrations of calcium (Ca), phosphorus, and potassium (P). The present study has documented that the levels of total dry matter, fat, protein, calcium, and phosphorus in milk derived from various goat breeds exhibit greater concentrations throughout the first and final stages of lactation. There have been reports indicating an inverse relationship between the quantity of milk and the concentration of solids within the milk. (13). The organoleptic qualities and minimal allergenic components of goat milk have garnered attention in industrialized nations. Dairy goat farming possesses distinctive attributes that render it a noteworthy choice for emerging nations. (14).

To ensure an efficient and sustainable milk production, it is important to possess a comprehensive understanding of the fundamental physiological mechanisms involved, as well as the judicious selection of animals exhibiting desirable yield characteristics. The physiological parameters under consideration encompass mammogenesis, the reproductive cycle and gestation duration, as well as galactogenesis and lactogenesis.

The endocrine system has significant importance in mammary development (mammogenesis), the beginning of lactation (lactogenesis), and the sustenance of milk production (galactopoiesis), surpassing the influence of most other physiological systems. Lactogenesis is commonly characterized as a two-stage phenomenon, wherein stage I denotes the partial development and functional specialization of the glandular epithelium in the mammary glands during the final trimester of pregnancy. Phase II encompasses the finalization of cellular differentiation in the vicinity of the periparturient phase, which aligns with the initiation of substantial milk production and release. The following are the fundamental developmental phases that encompass the physiological prerequisites that ultimately culminate in the process of lactation (15).

2. Morphological Structure of Mammary Gland and Mammogenesis in Goats

2. 1. Morphological and Histological Structure

The udder in goats is situated in the inguinal area and presents as a singular glandular mass, which is separated into two halves by the median inter-mammary groove. Each half, separated by the groove, possesses a single teat and udder component (16). The goat's udder consists of a sole udder unit, with each half including the glandular parenchyma (corpus mammae), duct system (papillae mammae), and cavity system (sinus lactiferi) (16, 17).

The mammary tissue of goats is a complex tubuloalveolar gland formed by lobules that are divided by connective tissue septae. The acinus, which is the site of secretion, is characterized by a layer of simple cuboidal epithelial cells. These cells have spherical nuclei that are located towards the center of the cell. The height of these cells varies significantly throughout different periods of secretory activity. The upper regions of these cellular structures are characterized by the presence of lipid vacuoles and protein granules that exhibit movement towards the outermost layer (18, 19).

3. Mammogenesis in Goats

During the developmental stage spanning from infancy to adolescence, the mammary gland experiences a significant developmental change, ultimately acquiring the necessary capabilities for milk production (20). During this period, mammogenesis exhibits allometric growth. The mammary gland has a phase of uninterrupted growth at the age of three months, exhibiting a significantly accelerated rate compared to other bodily regions. During the onset of puberty, there is an accompanying rise in the development of milk ducts and the proliferation of adipose tissue. The initial stage before puberty is distinguished by the elongation and reinforcement of the ducts located inside the core of the emerging tissue (21). It is of utmost significance to provide adequate space and offer required support for the maturation of the ducts, which in turn plays a crucial role in supporting the structural foundation of the alveolar system. The development of the mammary gland exhibits isometric growth starting with the onset of puberty (22). The proliferation of the mammary duct system is induced by estrogen, together with growth hormone and adrenal steroids. Furthermore, the hormones progesterone (Pg) and prolactin plays a crucial role in the formation of alveoli (17). During the initial stages of pregnancy, the development of the mammary gland exhibits allometric expansion, which may be attributed to the exponential augmentation in the quantity of cells and ducts. The ducts undergo elongation, leading to the replacement of the adipose tissue in regression by the lobulo-alveolar system. During the last stages of pregnancy, there is an observed increase in the volume of epithelial cells, accompanied by the development of distinct structures that facilitate protein synthesis and enable heightened secretion (23, 24). During this crucial phase, the augmentation in mammary gland weight is linked to the growth in body weight because of an increase in adipose tissue (25, 26). However, there exists an inverse relationship between the growth of mammary parenchyma and the rise in body weight. According to the findings of Harrisson et al. (27), it has been demonstrated that excessive body weight growth during the initial year of birth has a lasting detrimental effect on the mammary parenchyma. The aforementioned adverse impact does not manifest itself subsequent to the onset of puberty. Hence, any modification in the process of mammogenesis during the prepubertal phase, achieved by either low or high amounts of feeding or hormonal manipulations, has a significant influence on the future milk supply during the first lactation (28).

4. Reproductive Cycle, Pregnancy and Initiation of Lactation in Goats

Goats exhibit a reproductive pattern that is influenced by the yearly fluctuations in photoperiod. Various environmental and physiological elements, including as latitude and climate, food availability, breed, and husbandry system, exert an impact on the initiation and duration of reproductive cycles throughout the year (29). Goats, being animals with seasonal reproductive patterns, exhibit sexual behavior during the autumn season, coinciding with the period of decreasing daylight hours at higher latitudes (30).

The estrous cycle includes several morphological and physiological changes occurring in the ovaries and genital tract. These changes ultimately culminate in the manifestation of estrus (the period of male receptivity) and ovulation, as well as the preparation of the genital tract for mating, fertilization, and embryo implantation (29). The mean duration of the sexual cycle is 21 days and the length of estrus typically spans around 36 hours, however it can range from 24 to 48 hours. This variability is influenced by factors like as age, breed, season, and the availability of male breeders. The embryo migrates to the uterus around 4-5 days following conception and then undergoes implantation within a time frame of 18-22 days after the initiation of estrus. The mean pregnancy period is 149 days; however, there is observed variability of a few days across different breeds (29).

During the second trimester of pregnancy, dry period, the udder experiences a decrease in volume and a significant reduction in fluid content. During the latter stages of pregnancy, often occurring between 12 to 15 weeks, there is an observable augmentation in udder size, accompanied by the presence of extracellular fluid and a substance like milk that may be obtained from the udder. Simultaneously, there is an elevation in immunoglobulin levels leading up to the moment of birth. The secretion of colostrum, characterized by a high concentration of immunoglobulins and low levels of citrate and lactose, starts at the calf's initiation of suckling subsequent to birth. The concentration of immunoglobulin in the produced fluid undergoes a progressive decline, while there is a concurrent increase in lactose, citrate, and potassium levels. This transition from colostrum to milk is so facilitated (31).

5. Lactogenesis

Lactation physiology includes the development of the mammary gland from the fetal period to maturity, its further development during pregnancy and the onset of lactation, and the accompanying metabolic and behavioral adaptations. During the initial stages of pregnancy, the endocrine system experiences significant alterations. The regulation of mammary gland development involves several factors, including growth hormone, prolactin, adrenocortical steroids, estrogens, and progesterone. (32).

The concept of "lactogenesis" was initially established to describe the impact of lactogenic hormones on the mammary gland and the resulting histological alterations in the tissue. Later, lactogenesis came to be used to describe the formation of abundant milk during parturition and the emergence of structures involved in milk synthesis and secretion. Lactogenesis encompasses a biphasic procedure, comprising stage-I, whereby the synthesis of precolostrum occurs, and stage-II, which involves the secretion of significant amounts of milk at parturition. Lactogenesis refers to the biological process wherein mammary alveolar cells undergo enzymatic and cytological differentiation, leading to the release of milk. This process begins during early pregnancy and continues until full lactation is achieved following parturition (33).

Phase I of lactogenesis is distinguished by the enzymatic and cytological differentiation of alveolar cells. This phase may be further split into four distinct phases: the proliferative phase, which occurs during early pregnancy; the secretory differentiation phase, which takes place in mid-pregnancy; the secretory activation phase, which happens after parturition; and finally, the lactation phase. The proliferative phase commences promptly following pregnancy and is distinguished by a vigorous proliferation of mammary epithelial cells, as evidenced by increased DNA content. The process of epithelial cell proliferation leads to the formation of alveolar lobules, which then undergo further development into lobules that are capable of secreting milk. During the latter stage of pregnancy, there is a reduction in cell growth and an establishment of a network of small blood vessels around each alveolus (33).

The process of secretory differentiation commences during the latter part of gestation and is distinguished by a series of biochemical alterations that are essential for the commencement of milk production. These alterations include heightened activity of enzymes involved in lipid synthesis. The period of secretory activation is distinguished by the initiation of copious milk production, which occurs concurrently with a drop in plasma progesterone levels and a rise in prolactin levels following labor. Elevated levels of prolactin stimulate the transcription of genes responsible for milk protein synthesis. During this phase, the mammary epithelium undergoes cytological alterations that are characterized by an augmentation in the quantity of Golgi apparatus and endoplasmic reticulum. These organelles play a crucial role in the synthesis of diverse milk components. Lactose, protein, citrate, and salt have been identified as potential indicators of the secretory activation phase (33).

Continuous production of milk is an important characteristic of the last stage of lactogenesis. The phase may be further categorized into two sub-phases: the colostral phase, characterized by the presence of high levels of immunoglobulins and immunological defense proteins in the milk, and the mature secretory phase, characterized by a significant increase in milk production to sustain the baby during the breastfeeding period. The duration of lactation typically ranges from 210 to 280 days, with variations found among different breeds. The highest milk production during lactation is often recorded between 35 and 60 days after giving birth (34-37). The highest milk yield is observed in the lactation period following the 3rd or 4th birth (38, 39). The lactation phase is divided into 3 periods. These periods include 0-6 weeks covering the first lactation period, 6-27 weeks covering the middle lactation period and the last lactation period including the periods after the 27th week (Figure 1) (40). The lactation period is distinguished by the emergence of a dynamic enzymatic system responsible for the production of milk constituents and the fast growth of the mammary epithelium (33).

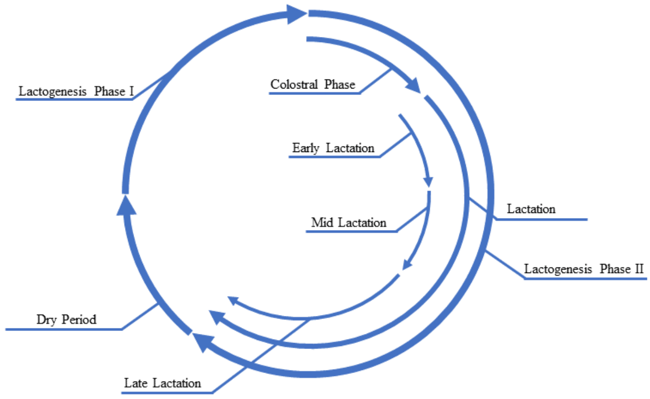

Figure 1. Phases within a Lactation Period

5. 1. Hormonal Control of Lactogenesis

Prior research has demonstrated that different hormones are involved in the process of lactogenesis. The hormones in question include prolactin, insulin, estrogen, progesterone, thyroid hormones, and prostaglandins. Insulin is involved in the regulation of energy distribution at the initiation of lactation (33). Prolactin, growth hormone, and insulin are important components of the lactogenic hormone complex, which regulates lactogenesis. Prolactin activates milk protein gene transcription by binding to plasma membrane receptors on mammary secretory alveolar cells (33). Prolactin levels increased 0.5-1 day before birth (41). Breast manipulation like sucking or milking releases prolactin (17).

As parturition approaches, estrogen levels rise, possibly affecting lactogenesis. Oestrogen induces lactation via increasing prolactin or the mammary glands prolactin receptor (33). Davis et al. found an increase in unconjugated estrogen three days before parturition in 1975. This rise continued until parturition, then dropped rapidly to barely detectable levels (41).

According to reports, there is evidence suggesting that progesterone has a role in the suppression of lactation. Additionally, it has been shown that progesterone levels drop during pregnancy-induced lactation, while there is a simultaneous increase in milk production. This suggests a correlation between lower progesterone secretion during the peripartum period and the onset of profuse milk secretion. Progesterone further inhibits the production of typical milk constituents, including casein, lactose, and α-lactalbumin. The mechanism hypothesized for the suppression of lactogenesis by progesterone involves the inhibition of either prolactin receptors or glucocorticoid receptors in the mammary gland (33). At the end of pregnancy, progesterone inhibits mammary cells' response to prolactation hormones such prolactin, placental lactogen, and adrenocorticosteroids. Decreased progesterone levels start profuse milk production (41). The lactogenic impact of thyroid hormones is likely attributed to their influence on the metabolic processes of the mammary gland and the absorption of nutrients into the mammary gland. Lactation increases the conversion of thyroxine to triiodothyronine, the physiologically active thyroid hormone, in the mammary gland. This keeps the mammary gland euthyroid, unlike other tissues. (33). Last but not least, prostaglandin F2α (PGF2α) acts as a local autocrine lactogenic inhibitor during the late stages of pregnancy. Immediately prior to delivery, there is a fast decline in the concentration of PGF2α in the venous blood. This decline is attributed to the metabolic activity of the mammary epithelium, which converts PGF2α into 13,14-dihydro-15, keto-PGF2α (DHKPGF22α). As a result of this metabolic process, the mammary gland is able to restore its secretory function. PGF2α is also accountable for regulating the permeability and secretion rate of mammary epithelial cells (33).

6. Galactopoiesis

Galactopoiesis refers to the process of sustaining and preserving ongoing lactation. The terminology is frequently employed to denote the enhancement of preexisting lactation. The maintenance of lactation is facilitated by a group of hormones referred to as galactopoietic hormones. The aforementioned hormones encompass prolactin, growth hormone, thyroid hormones, and glucocorticoids. Prolactin is the primary hormone responsible for stimulating milk production in rabbits, humans, and dogs. However, in ruminants, such as goats, prolactin is just one of several hormones involved in promoting lactation. Interestingly, inhibiting the release of prolactin in goats has minimal impact on milk production (33, 42). The process of galactopoiesis is intricately connected to both milk synthesis and milk elimination. To be able to sustain an adequate number of secretory cells, the mammary gland must engage in processes that promote cell growth and inhibit cell loss (42). In order to sustain lactogenesis, the process of milk production, it is imperative that milk is extracted from the mammary gland by either suckling or milking. The contraction of myoepithelial cells surrounding the mammary alveoli is facilitated by the hormone oxytocin. The release of oxytocin takes place in the posterior pituitary gland within seconds of sensory impulses reaching the hypothalamus, and its effects last for a duration of several minutes. (17).

6. 1. Factors Affecting Galactopoiesis

The continuity and yield of lactation can be influenced by several factors, including the number of births, calving interval, breed, photoperiod, lactation season, frequency of suckling and milking, size and number of calves at birth, general health state, and ration. (34, 43-45).

6.1.1. Time of Birth, Lactation Number and Photoperiodism

In the Northern Hemisphere, the parturition of goats often takes place around the month of March, although the dry phase is commonly observed in November or December (30, 46). Previous studies has indicated that lactation milk supply in goats is much greater for those who have parturition between the months of January to March, compared to those that give birth between April and June (43, 47).

The number of births affects milk fat and protein concentrations, yield and somatic cell count. The somatic cell count in milk increases as the lactation progresses and the number of births increases in a normal goat. This increase can be more than 1,000,000 cells/ml in milk after the 5th lactation (48). The milk production of primiparous dairy goats is comparatively lower than that of multiparous dairy goats. The peak milk production is observed during the third or fourth parity, as indicated by previous studies (38, 39).

The phenomenon of photoperiodism, particularly when there is an extended duration of daylight exposure, has been found to enhance the production of lactation milk in goats at both late and early stages of lactation (49-52).

6. 1. 2. Prolonged Lactation Period

The duration of lactation has a notable impact on the quantity of milk produced, as well as the composition of the milk, with extended lactation periods resulting in greater milk supply and higher levels of milk components (43). According to the findings of Watkin and Knowles (1946), it was observed that goats had the ability to sustain continuous lactation for a duration of 24 months (53). In a separate investigation, Brice (2000) conducted an examination whereby it was discovered that the longer lactation durations of primiparous females exhibit two distinct stages in terms of their curves. During the initial phase, which included the initial 10 months of lactation, a typical lactation curve was seen. The subsequent phase, encompassing the final eight months of lactation, had a resemblance to the typical lactation curve observed in the subsequent lactation (54). According to Brice (2000), it was shown that the last stage, albeit being lower in magnitude compared to the preceding lactation curve, exhibited comparable milk production amongst females having prolonged lactation and those undergoing two regular lactations (54). The individual posited that this phenomenon may potentially be attributed to the extended duration of breastfeeding. In addition to the aforementioned factors, there have been reports indicating a reduction in milk production among goats that conceive during the lactation period (55).

Based on the findings of the studies, it was determined that goats do not require a dry interval for udder involution, in comparison to dairy cattle (43). In a research investigation comprising four caprine subjects, one mammary gland had uninterrupted milking for a duration of 66 weeks, while the second unit was subjected to milking for a period of 25 weeks, followed by a drying phase of 23 weeks throughout the reproductive and gestational stages, and then resumed milking for a span of 18 weeks. Over the course of the last 18 weeks of lactation, it was seen that the gland subjected to continuous milking had a tendency towards increased milk supply, larger parenchyma weight, and a higher count of secretory cells. Nevertheless, the enzyme activity in the mammary glands did not exhibit any significant differences (56).

6. 1. 3. Suckling and Milking Frequency

There are notable distinctions between goats and dairy cattle in terms of the neuroendocrine milk evacuation reflex. This disparity can be attributed to the comparatively larger milk storage capacity found in the mammary gland cistern of goats (57). Consequently, this suggests that natural suckling may provide substantially less milk production advantage in goats compared to machine milking. Nevertheless, there have been notable variations in performance outcomes between dairy goats that are suckled and those that are machine-milked, with the extent of these variances being highly dependent on the specific experimental or production settings. (43).

6. 1. 4. Genetic Composition

Genetic effects occur individually and collectively. Individual genetic effects can be seen in expected progeny differences calculated annually by USDA-AIPL (58). The collective effect is seen as breed differences due to genetic differences. An example of this is that Swiss breeds (Alpine, Saanen and Toggenburg) can yield more than Nubian and LaManchas breeds. (59).

6. 1. 5. General Health Conditions

The significance of maintaining proper hygiene practices in milking and milk processing is evident in its impact on bacterial levels and somatic cell counts. According to the study conducted by Delgado-Pertínez et al. (2003), the main cause of microbiological contamination in dairy goat farms in Spain was identified as the inadequate hygiene practices and incorrect chilling during the process of transferring milk from the udder to storage in the farm or cooperative tank (60). Enhanced management practices, such as ensuring proper cleanliness of the farm, animals, and milking parlor, using udder sealing techniques, maintaining milking equipment, and promptly transferring milk to the storage tank following manual milking, have the potential to decrease both bacterial counts and somatic cell counts. The need of maintaining proper hygiene procedures is heightened throughout both wet and dry seasons. Moreover, there exists a disparity in microbial counts and somatic cell counts between hand-milked and machine-milked milk. However, it is worth noting that this discrepancy may be subject to several causes, including breed variability. (43).

6. 1. 6. Ration

The correlation between the quality and content of the ration and yield metrics, particularly in ruminants, is a significant determinant. The adjustment of the mix of concentrate and roughage, as well as the levels of protein, fat, and fatty acids in the ration, is crucial in achieving the optimal yield characteristics. The impact of crude protein (CP) levels in the diet on milk production and composition is contingent upon the specific nitrogenous components that influence the intake of metabolizable protein. Nevertheless, when the ration CP levels exceed the milk synthesis capacity, the efficiency of CP use remains relatively low, irrespective of the source of CP (61). Previous research has proposed that dairy goats have a lower degree of sensitivity towards bypass protein (BP) supplementation compared to dairy cattle (62). Nevertheless, the reviewed studies observed conflicting outcomes regarding the impact of increasing BP supplementation on milk production in goats (63-66).

The physico-chemical properties of diets, such as particle size and the ratio of concentrate to forage, have an indirect impact on milk fat content, milk production, and milk dry matter content by influencing calorie intake. The impact of these effects may be very insignificant in animals that have moderate to low milk production, however it has been shown that milk fat concentration tends to rise when the full capacity for milk yield is achieved. It is widely recognized that insufficient quantities of dietary fat might result in decreased milk fat content (43).

7. Conclusion

It is important that the husbandry of goats, whose care and feeding conditions are less laborious compared to other animals and which stand out with their milk containing rich content composition, low lactose levels and antiallergic properties, should be carried out by taking into account the physiological state and requirements of the animal. In this case, it is thought that having knowledge about the concepts of "reproductive cycles and pregnancy periods, mammogenesis, lactogenesis and galactopoiesis" can better meet the needs of the needs of the animals and can improve the milk yield parameters which are emphasized.

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