Chapter

Nutrition for Lactation of Dairy Sheep

Houcine Selmi, Amani Bahri and Hamadi Rouissi

Abstract

The feeding of dairy sheep has to start exactly at the beginning of the last 2 months of gestation (the last third of gestation) and not after lambing. Indeed, during this critical physiological stage, the rumen is compressed by the uterus. Therefore, the ewe can no longer ingest the amount of food that can satisfy its ingestion capacity (2–2.5 kg DM/100Kg of weight/speed) which leads to a controversial situation therein the fact that on the one hand the needs are high (maintenance and gestation) and on the other hand the ingestion capacity is decreasing. To solve this issue, we should give the ewe a supplement based on good quality food that is not heavy and that favors rapid digestive transit. Thus, this supplement must be a concentrated feed distributed at a rate of 0.3 FU/ewe/day), during the last 2 months of gestation. This feeding technique makes it possible to have vigorous lambs at birth, a satisfactory colostrum production which makes it possible to give the lambs the antibodies, necessary for their passive immunity, and therefore reduce the perinatal mortality rate as well as allow for a good triggering of milk production which will be increased in the quantity produced and the peak of lactation. In general, the ration must always be balanced in energy and protein. Indeed, if the ration is surplus in energy, it can cause the infertility of ewes. If it is the other way around, the urea will be stored in the liver and transformed into the urine. However, if the excess is intolerable, it will persist in the liver and cause mortality of the animals and diseases, such as alkalosis. In addition to proteins and energy, ewes must receive the necessary minerals, mainly Ca and P, during pregnancy and lactation. A deficiency of Ca at the end of gestation will cause milk fever (hypocalcemia) which will not be recoverable later. Finally, excessive watering should be avoided after a water is cut to prevent diarrhea.

Keywords: nutritional disorders, deficiency, dairy sheep, gestation

1. Introduction

The development of ruminant livestock farming in the Mediterranean area involves different sciences (nutrition, reproduction, genetics, health) which must be conducted in parallel and in an integrated way in a breeding system. The conditions of the rearing environment (temperatures, humidity, pathologies, forage quality, etc.) are difficult and limit individual performance (production of milk and meat). Ruminant feeding in the tropics has been the subject of much work, and several approaches have been developed. The first approach focused on improving the quality of the basic ration. The low nutritional value of tropical forage is one of the main factors limiting animal performance [1]. Various works were carried out to improve the nutritional quality of the fodder, and so many varieties were distributed. Improved digestibility and ingestibility of forages, by physicochemical treatments, on the one hand, and by urea treatment, on the other hand, were also studied [2, 3]. However, the ingestibility of these forages, their protein, and energy value remained lower than those used in temperate zones and do not cover the needs of our herds. This leads to a massive reliance on imports of animal products like dairy and meat products.

Indeed, after the good period of reproduction, the feeding behavior of the ewes at the end of gestation must allow to successfully bait and ensure a good start of lactation. Reasonable dietary behavior over the last 6 weeks of gestation strongly contributes to a good birth weight of lambs, longevity, and body condition of the ewe [4].

In theory, the needs during the control period are not different from those of the maintenance, but the overfeeding practiced (flushing) during this fight influences the egg-laying and also the grouping of the calves allowing a better control of the notion of allotment.

On the other hand, many authors have reported that diet influences prolificacy. Indeed, stimulation of ovarian activity promotes ovulation rate (based on live weight and weight gain before the fight). The heaviest ewes have a higher ovulation rate. Hence, the interest of pre-estrous flushing, which improves the number of agneaus born from 10 to 20%.

In Tunisia, the Sicilo-Sarde breed is a medium-sized sheep breed with a height of 0.7–0.8 m, heterogeneous in color with the dominance of white, with a medium weight of ewes, 40 kg and 60 kg for rams. The head is slightly elongated without horns. The neck is moderately long, the members are long and thin, and the trunk is elongated with a full belly. The udder is well developed with a strong attachment and with straight nipples. Breeding performance of the Sicilo-Sarde breed depends on several factors, such as driving, feeding, housing, and genetic factors [5]. The herd is conducted in a semi-intensive system [6], characterized by rations consisting of hay, thatch, natural pastures, crop residues, and greenery (barley in green, bersim, etc.). The use of the concentrated feed takes place throughout the year in varying amounts. Figures from the Ministry of Agriculture show that the numbers of this dairy breed are in constant decline. For this, many questions have been raised about the profitability and sustainability of this breeding [6–13].

2. Physiology of lactation

2.1 Morphological and anatomical description of the mammary gland

The udder is an exocrine gland composed of two independent quarters, located on the ventral side of the animal in inguinal position. The right and left quarters of the udder are separated by a central suspension ligament composed of elastic tissue. Branches of this ligament can extend into the quarters. The udder is covered with elastic skin [14]. It can be enlarged by the accumulation of milk between two milking or between two feeding. In lactation, each quarter contains secretory tissue consisting of mammary epithelial cells, milk ducts, a gland cistern, and a teat [15, 16].

The mammary epithelial cell is a secretory cell constituting the smallest cell unit (or acini). In lactation, the epithelial cells are polarized, with the basal side on the basement membrane side and the luminal side located on the alveolar lumen side. The constituents of the milk are secreted in the alveolar lumen by the luminal side. The epithelial cells are bound together by tight junctions and are based on a basement membrane consisting of laminin, collagen, and glycosaminoglycans. Epithelial cells contain basal part of the nucleus, surrounded by granular endoplasmic reticulum.

In the direction of the apical plasma membrane, cytoplasm contains the Golgi apparatus and secretion of different units: the lipid droplets and the secretory vesicles. The apical plasma membrane forms microvillus [17]. The synthesis of milk fat takes place within the endoplasmic reticulum and is materialized by the formation of lipid droplets between the two membrane layers of the reticulum. Once formed, the lipid droplets migrate to the apical membrane according to mechanisms that have not yet been elucidated. Lactose is synthesized in the Golgi apparatus and accumulates in secretory vesicles. Proteins are synthesized by ribosomes located on the surface of the granular endoplasmic reticulum. They, then, pass through the Golgi apparatus or begin the maturation process (phosphorylation, in particular) before being included in secretory vesicles [18].

2.2 Hormonal mechanism of milk secretion

The onset of lactation or milk production is the result of the effect of two pituitary hormones, namely, prolactin and growth hormones [19]. The role of these hormones is inhibited during pregnancy by high levels of estrogen and progesterone; after lambing the sudden drop in these hormones allows the secretion of prolactin and, therefore, the onset of lactation [16]. Prolactin and GH play a pivotal role in the transition from the mammary gland proliferation phase to the milk secretion phase by acting either directly or via the mammary epithelium-secreted hormones that activate the transcription of the mammary gland. Other factors that ensure the onset of lactation [20]. Cannas et al. [21] reported that maintenance of milk synthesis and secretion is controlled by the interaction of systemic factors and local regulatory factors, whereas throughout lactation milk synthesis decreases because of increased doses of estradiol and progesterone [19].

Refs. [22, 23] have reported that GH-specific receptors are absent in the mammary gland, so this hormone exerts its positive effect on milk production, indirectly, by stimulating synthesis and secretion of insulin growth factors whose receptors have been identified in the mammary gland of the ovine species. Aside from its role in triggering lactation, this hormone (GH) increases blood circulation and increases mobilization of body reserves [24].

2.3 Mechanisms for evacuation of milk

Milk is synthesized in mammary epithelial cells lining the alveoli from the nutrients provided by the blood vessels that come in contact with them. The synthesized milk is secreted in the alveolar lumen [25]. There are two mechanisms of milk evacuation; the first is the flow of milk by contraction of smooth muscles, and the second is an ejection reflex. The first mechanism for evacuating milk is the flow of the latter after opening the sphincter under the effect of the pressure of the teat at the beginning of milking. This mechanism starts 5–10 s after teat stimulation. It involves the contraction of the smooth muscles surrounding the canals, causing the evacuation of the milk they contain [10]. This flow phase allows the evacuation of 40–50% of the milk produced. The second mechanism is the milk ejection reflex. During the first stimulation of the teat or the animal (smell, vision, hearing), nerve impulses go from the teat (or any other sensory organ) to the brain, which then releases into the blood a hormone of the hypothalamo-hypophyseal complex: oxytocin. This hormone acts on the myoepithelial cells surrounding the alveoli causing their contraction [9]. Under the contraction of the myoepithelial cells, the cells are pressed causing the ejection of the milk contained in the acini lumen toward the terminal ducts and then the intralobular, interlobular, and interlobar ducts where it reaches the cistern of the gland and then that of the teat. The milk ejection reflex usually takes place 20–30 s after the initial stimulation [26]. In this same context, [25] have shown that the level of secretion of oxytocin differs significantly depending on the season in the Lacaune race, as the level of secretion in autumn is higher than in spring (27.5 ± 1.9 μg/ml against 12 ± 1.4 μg/ml, respectively).

3. Dietary requirements of dairy sheep during gestation

3.1 Feeding gestante females

As we have reported, the feeding of pregnant females, especially during the last third of gestation, has an impact on fetal weights, vigor of newborn lambs, mortality, milk production of the mother, growth rate of lambs, the onset of pregnancy toxemia and body weight, and maturity on sale. As a result, this energy, protein, mineral, and vitamin diet can be broken down into three periods.

In early pregnancy, fetal growth is minimal, and the feeding requirements of ewes differ a little from those observed at the maintenance stage. We can therefore give the ewes a similar ration in a slightly higher quantity. Grain is rarely needed early in pregnancy unless forage is of poor quality and the body condition of the ewe is affected.

At the beginning of gestation (1 month), any sudden modification of the diet during this period can cause embryonic mortalities. The embryo settles 16 days after fertilization. In the second period, during the mid-gestation period (2nd and 3rd month), the animals' needs are still low; they are equivalent to those of a maintenance of a female (**Table 1**).

The third period, which is the end of gestation period, is the most critical period, as the needs are higher and higher because of the development of the fetus or fetuses. The volume of the uterus takes more and more place in the abdomen; it also compresses the digestive tract. The capacity of ingestion of the ewe decreases strongly; it requires a complementation with a small food (food has a fast digestive transit) which is especially rich in energy. This complementation is called steaming.

Live weight	FU	DNM
05	0.18	15
10	0.26	22
15	0.33	28
20	0.38	32
30	0.47	40
40	0.53	45
50	0.59	50
60	0.65	55
70	0.70	60
80	0.74	64

FU, fodder unit; DNM, digested nitrogenous materials.

Table 1.
Maintenance needs of sheep in FU and DNM.

In addition to lactation, this is the most nutritionally demanding stage because of fetal growth and the development of milk production potential. More than 80% of fetal growth occurs during the last 6 weeks of gestation. A deficient nutrition (especially in energy) during this period has detrimental effects on the milk production of the ewe, the birth weight, and the vigor (survival potential) of the lambs. Ewes must receive at least 335 g (0.75 lbs. of a mixture of grains, per ewe, per day, for those with a lambing percentage greater than 200%.

During calving, the ewe will experience a relatively low intake because of the loss of appetite. Thus, to cover the needs of lactation (0.6 FU and 120 g DNM/liter of milk), the diet must be based on grazing or feeding in green along with a feed-concentrated supplement, to allow the ewe to restore fat reserves lost in late gestation.

It is strongly recommended that the grass should not be young to avoid certain diseases such as grass tetany, resulting from Mg deficiency, which can lead to ewe mortality. The greenery should not be rich in legumes to avoid weathering resulting from a buildup of gas in the rumen that would cause digestive disorders.

The mineral requirements of sheep during the gestation and milking phase are summarized in **Table 2**.

A deficiency of nitrogenous materials and minerals always has regrettable consequences on the viability and the weight of the lambs. An important energy undernourishment causes an excessive mobilization of the reserves bodily, risking of a toxemia of gestation. To remedy this difficulty and ensure a good start of lactation, it is recommended to:

- Scan ewes and separate those with single lambs from those with double lambs.
- Make the batches according to the body condition.
- Avoid manipulations, especially thermal stress.

The success of the births needs a food preparation. In practice, it is necessary to provide energy intakes equal to 1.5 times that of maintenance during the last 6–8 weeks of gestation for ewes carrying multiples. Indeed, we use steaming which is an operation of providing a complement to the ewe during this critical phase. This supplementation varies according to the state of the courses at the rate of 200–400 g of concentrate, per day.

Physiological stage	Ca	P
Month of gestation		
2	05	04
3	05.5	04
4	08.5	05.5
5	08.5	05.5
Lactation month		
1	14	09
2	12	08
3	10	07
4	08	06

Table 2.
Mineral requirements according to the physiological stage.

3.2 Feeding lactating females

During the first month of lactation, the lamb is dependent on the milk production of the mother. Needs are important, but the ingestion capacity is limited for 3 weeks. The maximum milk production level is reached very quickly after the farrowing period:

- At 15 days when the ewe is nursing two lambs.
- At 3 weeks when the ewe is nursing one lamb.

During this period, the energy balance is negative, and the animal can on his bodily reserves. We accept a loss of weight of 2 kg per month (1–4 kg depending on the state of the female before the birth).

Lactating ewes typically reach maximum milk production 3–4 weeks after lambing and produce 75% of their total milk yield during the first 8 weeks of lactation [2]. The ewe that seals two lambs produces 20–40% more milk than the one that only feeds one.

As the growth of lamb is paramount and depends on the production of sheep's milk, it is essential to optimize milk production. Too often, we see herds where ewes do not receive sufficient amounts of food in relation to the number of lambs they breastfeed. In most cases, the rations do not contain a sufficient proportion of grains during the first 4–6 weeks of lactation, which results in energy deficiency and often protein. In ewes, milk production depends on the same diet as in dairy cattle.

During this period of lactation, it will be necessary to:

- Cover the nitrogen requirements of mothers (they have more reserves).
- Limit the energy deficit knowing that the animal mobilizes its reserves.
- Ensure ingestion capacity. In fact, it reaches its optimal level again 5–6 weeks after lambing.

The above information discusses production stages in the case of lambing, once a year, whether in summer or winter. To be successful, pastoralists who adopt an accelerated lambing program must ensure that the health status of their ewes is above average. Ewes should not lose too much weight during lactation if the breeder expects that they are giving birth again and is performing well in the number of lambs and their weight at weaning.

The most often overlooked step for good herd nutrition is the assessment of body condition. The farmer must measure the body condition of his flock to determine how ewes respond to feeds. If this step is neglected, forage sampling and ration evaluation will be unnecessary. The farmer must evaluate how the herd reacts to the food provided to them. In the absence of an assessment of body condition, good herd nutrition cannot be achieved.

4. Effect of diet on the production and composition of sheep's milk

Food is one of the main factors conditioning animal production. Its effects can be noted on the quantity as well as the quality of the animal products. In dairy sheep, milk production is dependent on the level of food and the quality of the constituents of the diet [27].

A study conducted by [28] on two forage species, barley in green and vetch with or without supplementation, showed that total milk production was not affected by complementation, as well as daily production was 460 and 430 ml, respectively, on barley and vetch with no significant difference, while milk produced on vetch is richer in fat and protein ($p < 0.05$).

In the same context, [6] mentioned that the amount of milk produced by Sicilo-Sarde ewes grazing oats is higher than on pasture of *Phalaris*. Milk produced with a pasture-based diet is richer in fat and protein than that produced by sheep fed with hay and silage in sheepfolds [29, 30]. These results have been confirmed by [7] who have argued that the milk of ewes fed with green fodder supplemented or not is richer in fat (77.4 vs. 69.1 g/kg) and in proteins (62.4 vs. 59.4 g/kg).

The use of legume pasture such as bersim, sulla, and medicago significantly increases the protein quality of sheep's milk and the level of production [31], leading to an intense marketing of milk and a quality of cheese. Better and with less burden because of the low use of the concentrated feed [32]. Similarly, [33] showed that the herbage was accompanied by very important changes in most milk characteristics, and in particular the urea content (+0.12 g/kg between samples taken in March and May) and mineral contents (respectively, +0.06 g/kg, +0.09 g/kg, −0.26 g/kg for calcium, phosphorus, and citrates).

Pirisi et al. [11] tested the effect of diets on the physicochemical and microbiological characteristics of milk produced by Sardinian ewes fed with hay, silage, and mixed concentrate (R1) and with ryegrass grazing. Italy (R2) showed that the level of butyric spores was higher ($p < 0.01$) in milk R1 (1140 vs. 20 germs/l) and the concentration of somatic cells was higher in milk (R1), while the fat content is higher in cheese (R1) characterized by a poor structure (**Table 3**). Similarly, [34] reported that milk production increases during winter–spring with pasture and supplementation only during the autumn (pasture alone). In the same context, the ejection of ewes previously fed with preserved fodder results in an increase in milk production, which leads to a second peak of lactation around March [29, 35].

Atti et al. [36] reported that the amount of milk produced by Sicilo-Sarde dairy sheep on green barley or fat strip grazing was significantly higher ($p < 0.05$) than that of ewes receiving milk. In sheep-fed silage (616, 618, and 363 ml/day), the fat content and the protein content are higher for sheep in sheepfold than for ewes grazing barley in green or fat ray (**Table 4**). However, there is no significant difference in either production or milk quality between the two pasture forage species ($p < 0.05$).

The milk content in urea nitrogen depends on the protein content of the ration; it is better correlated with it (R2 = 0.82) than with the amount of protein ingested (R2 = 0.56), which is in fact an effective indicator of nitrogen use [37]. The urea content of milk varied between 12 and 27 mg/dl depending on the protein level

	R1	R2
pH	6.6 ± 0.03	6.72 ± 0.03
Solide total (g/100 g)	18.54 ± 0.42	18.09 ± 0.28
MG (g/100 ml)	7.24 ± 0.37	6.98 ± 0.33
MP (g/100 g)	5.28 ± 0.12[a]	5.66 ± 0.11[a]
Casein (g/100 g)	4.26 ± 0.16	4.36 ± 0.17

[a]*The averages of the same line bearing different letters are significantly different ($p < 0.01$).*

Table 3.
Physicochemical criteria of milk from ewes fed at the trough or on pasture.

	Bergerie	Orge en vert	Ryegrass	ESM	P
Milk production	363	616	618	37.5	***
FAT	88.8	77.2	76.8	1.15	***
Protein	57.6	54.6	53	0.51	***

****p < 0.01; ESM, error standard mean [36].*

Table 4.
Average production (ml/day) and milk composition of Sicilo-Sarde sheep according to the food mode.

of the diet: these values, lower than those measured in dairy cows, are consistent with those observed on Lacaune ewes during the milking phase, when increase in the coverage rate of average needs in DINP (from 120 to 160%) causes a significant increase in the content of milk in urea (from 38 to 52 mg/dl, i.e., + 36%) which is linked (R2 = 0, 90) imbalance (DINP-PDIE)/UFL rations [38], while total dry matter intake does not affect milk urea [9, 39].

Ewes fed with a 34.1% starch concentrate produce more milk than those receiving a 12.2% concentrate (1.088 vs. 0.902 kg/d), without affecting milk fat and protein composition (TB, 8.04 vs. 8.57%; TP, 5.96 vs. 5.83%, respectively), for starchy and starchy concentrate feed [40]. On the other hand, [41] reported that a food rich in starch that is rapidly fermentable in the rumen leads to a more intense production of propionate and a drop in the milk fat content. In addition, the same authors reported that there is no systematic influence of the rate of starch degradation on protein levels and raw milk yield when comparing corn and barley. However, Sinas et al. [42] have shown that when rations comprise a large proportion of untreated sorghum which is the richest cereal in terms of slow starch, there is a decrease in milk yield compared with sorghum treated with steam under pressure. These results may reveal the existence of a maximum threshold not to exceed protected starch in the diet [43]. The relationship between volatile fatty acids and ruminal pH, on one side, and the production and composition of milk, on the other, has been studied by [44]. Thus, the proportion of propionate and butyrate is positively correlated with the amount of milk unlike acetate, while the butyrous rate evolves in the same direction as the C2 and conversely with C3 and C4.

5. Conclusion

Since there is a great deal of variation in the quality of the fodder, their analysis is paramount and must include the following nutrient content: crude protein, acid detergent fiber (FDA), calcium, phosphorus, magnesium, potassium, and possibly even micronutrients (copper, manganese, and zinc), understanding the changes in nutrient requirements according to the production cycle. To easily manage sheep farming and meet their needs, it is essential to know at all times the production cycle of sheep and each group of ewes, to be able to separate the sheep and ensure adequate management of each group. Regardless of the production system adopted by the farmer (accelerated or once a year), profitability is closely linked to a nutrition adapted to the production cycle, to know at what stage of production are the ewes you feed and to reduce feed costs by avoiding unnecessary overfeeding. The production cycle of the ewe is generally considered to have six important stages of production: maintenance, intensive feeding, early gestation, late gestation, and early lactation. Management in general, and more specifically nutrition management, should be modified at each of these stages if the farmer wants the herd to be healthy and above all to obtain a satisfactory selling price.

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