Chapter

Lactation Performance of Small Ruminants in the Maghreb Region

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Abstract

Maghreb areas are characterized by rainfall seasonality and scarcity resulting in a low fodder potential. In these arid and semiarid regions areas, small ruminant production is the main source of income of farmers living where sheep (*Ovis aries*) and goats (*Capra hircus*) are generally confronted with severe nutritional deficits during feed scarcity period which exacerbate disease and health troubles and consequently low performances. Interestingly and despite the importance of the milk performance to the dairy industry, very few works studied the potentialities of the mammary gland through the lactation period both in sheep and goats elevated in the Maghreb areas. Nevertheless, understanding the different mammary gland patterns throughout lactation is essential to improve dairy production and to reduce poverty and vulnerability in rural farming systems in these developing areas. The main objective of this review is to analyse the lactate processes as well as to underline the mammary gland morphological patterns, health and physiology traits and to evaluate milk potentialities of the main breeds of goats and sheep raised in Maghreb.

Keywords: sheep—goats—milk, Maghreb areas

1. Introduction

Nowadays, dairy foods represent one of the most dietary dense food, being considerable sources of numerous nutrients, mainly calcium, riboflavin, phosphorus, protein, magnesium, vitamin B12, niacin equivalents, vitamin B6, and when fortified, vitamins A and D. Milk and dairy products are also one of the major sources of nutritional calcium which is essential both in bone development, and the maintenance of healthy teeth [73].

In the Mediterranean zones, dairy sheep and goats rural managements diverge from pastoral (showed irregular milk production, dual-purpose breeds, insignificant feed supplementation, transhumance, hand milking, absence of farm facilities, farm-made cheese) to intensive management (continuous milk production, enhanced local breeds, valorization of forage crops, feed supplementation, machine milking and farm facilities, profitable cheeses) according to the profitable impact of the production chain and the specific environment and breed [1].

The Mediterranean small ruminant dairy sector is original and very diverse. More than 46% of the dairy ewes in the world originates from the Mediterranean region. The major countries, in terms of the flock of dairy ewes and goats, are Greece, Italy, Spain, France and Turkey in Europe, and Algeria, Tunisia, Egypt and Libya in North Africa [2]. In North Africa, where there is no strong dairy tradition,

ewe and above all goat milk is used mainly for family consumption likes as milk or white fresh cheese the 'Jben Arbi'. It has been considered that milk has a symbolic value of life and fertility in the Maghreb regions, as it is often used, with dates, in ceremonies to welcome guests according to the Berber and the Arabic traditions [3]. In these regions, small ruminant and camel constitute the most valuable activities in arid areas based on their resistance to dry or hot conditions. This resistance to harsh conditions evaluated in terms on adaptive traits or rusticity, is based on different abilities: mobility, physiology, feeding pattern, etc. Furthermore, sheep and goats need low investment resources and fast rate of reproduction covers short term expenditures.

In such developing countries of Maghreb, dairy production is an essential tool to overcome social and economic issues like as poverty and human malnutrition [4]. However, despite its potential contribution to sustainable economic growth and poverty drop, dairy sheep and goats sector has received restricted attention from Maghreb Nations in recent decades. Furthermore, little is known about dairy sheep and goats reared in Maghreb Nations [28, 52] and a better knowledge of these genetic resources can help promote their conservation and efficiency benefits. Therefore it is critical to understand the modifications associated with lactation in the mammary gland in order to develop strategies to improve milk yield or reduce the constraints that decrease milk production and milk quality in dairy Maghreb sheep and goats. Considering the current significance of sheep and goat milk production, this review draws a study to analyse the lactate processes as well as to underline the mammary gland morphological patterns and physiology traits and to evaluate milk potentialities of the main breeds of sheep and goats raised in the Maghreb areas. Overall, such data will be important in supporting further studies aimed at improving lactation potentialities, among other factors, with benefits for this emerging dairy sector for both the industry and the consumer.

2. Overview on Maghreb areas

Located in the Northern fringes of Africa, the Maghreb areas (Lybia, Tunisia, Algeria and Morocco) have a long tradition with dairy products' consumption. The Maghreb countries are distinguished by their typical Mediterranean climate; a long summer (May to September) with an intense drought and excessive heat and often an irregular rainfall from autumn to spring [5].

Another trait which distinguishes the Maghreb climate, the marine effect which reduces the amplitude of temperatures in zones near to the landfall: the Mediterranean in Morocco, Algeria and Tunisia and the Atlantic Ocean in Morocco. The normal annual precipitation is less than 300 mm in wide regions of the Maghreb countries, engendering arid to semi-arid climates [6].

Therefore water scarcity constitutes the main limiting factor to agriculture. Hence, the agricultural output in the Maghreb remains largely related to the level of annual rainfall in rain fed areas [9], with no opportunities of irrigation. The hydrological water stress index is respectively 29, 11 and 3 in Algeria, Morocco and Tunisia. Such index implies that at the regional level, Algeria and Tunisia face the highest level of water stress, while in Morocco water is less scarce [7]. This situation will certainly widen with the expected demographic growth and climate change, and consequently, have negative repercussions [8].

The photoperiod is another significant factor that affects sheep and goats productivity especially in breeds that originate from geographical areas at high latitudes. Thus, appropriate supervisory policies must be developed to allow milk production out of season in small ruminants [1].

3. Review on lactogenesis and mammary gland traits

Lactogenesis may be defined as the beginning of milk secretion [12]. This physiological mechanism can group two stages. The first stage occurs during pregnancy when the gland is adequately differentiated to produce little amounts of specific milk components like lactose and caseins [13]. The second stage can be defined as the start of copious milk liberation depended to parturition. Nutrition during pregnancy is the most factor that affects both colostrum yield and composition [14]. When small ruminants are kept under poor grazing conditions, there is a general mobilisation of their body reserves during the last 6 weeks of gestation owing to rapid fetal growth and colostrum yield [15, 16].

The structure and the function of the mammary gland are coordinated by the neuroendocrine control from the development of the gland via the milk ejection. The main role of the endocrine mechanism is to synchronise mammary function and development with the reproductive stage, while the main role of the nervous mechanism is to stimulate the process of milk removal. These two mechanisms are joined in the hypothalamic-pituitary axis, and manage the entire process of milk production through the release of several crops (lactose, prolactin, oxytocin, growth hormone, etc.) as well as the coordination of other hormone-releasing organs, i.e., mammary gland, placenta, ovaries [17]. The proliferation of mammary tissue may be activated by the prolactin secreted in response to the gland stimulus.

However, other factors of the normal mammogenic complex are either entirely absent during lactation (e.g., placental lactogen) or just present in small amounts or at specific moments (e.g., oestrogen) [18].

Suppression of prolactin secretion in goats and sheep [19, 20] had only partially in sheep lactation. This hormone is at least as important as growth factor in maintaining goat milk yield [21].

When it was administrated to pre-pubertal young ewe, the bromocriptine (prolactin inhibitor) had no effect on the mammary development [22]. However, a treatment with progesterone in post-pubertal ewes suppressed the epithelial proliferation [23].

The completion of tubuloalveolar development in ewes ultimately requires oestrogen and progesterone in the presence of endogenous prolactin [24]. One of the classical roles assigned to oxytocin is milk ejection from the mammary gland. Although it is mainly associated with milk ejection, treatment with exogenous oxytocin was associated with increased milk production in sheep [25]. The major amount of the milk is accumulated in voluminous cisterns of the goat gland thus it can be remote through by suction applied to the nipples. Hence, a milk discharge reflex is not necessary for the nourishing of the young, though it could help the process [25, 26]. In fact it is possible to identify goats with very high milk yield and either strong milk flow rate that have no appreciable increases in plasma oxytocin concentrations during milking [27]. Perhaps this finding is indicative of a lower dependency on oxytocin for milk removal in goats.

In small ruminant mammary gland, the glandular parenchyma is responsible for milk production and is constituted by tubule-alveolar glands relative to its anatomical organization; it has two main components, (1) the parenchyma which includes the epithelial and myoepithelial cells, (2) the stroma involving the non-cellular components, as collagen and elastin, smooth muscle cells and vessels and the ductal system [29]. However, it is important to note that anatomy and histology of the mammary gland are changed during the lactation stage, mostly led by the neuroendocrine mechanism. There are three stages of mammary biology characterising the pregnancy/lactation periods: proliferation, secretion and involution. While the most proliferation happens throughout gestation and most of the involution occurs

after lactation has finished, such processes coincide: proliferation of secretory tissue persists during early lactation and involution initiates during late lactation, simultaneously with milk secretion [30].

Concerning the lactation period, it differs between small ruminant species. In sheep lactation, it lasts for 5 months with a peak between the weeks 3 and 4 [23, 31]. In contrast, the lactation period in goats lasts for 10 months with a peak between weeks 5 and 10 [32]. These values are highly dependent on breed and nutritional status, among other factors [33].

By studying the mammary gland volume changes in goat breeds (Toggenburg, Nubian, Saanen and French Alpine) during various physiological stages [34, 35], no differences were detected in udder weights during pregnancy until day 120, when values started to increase significantly. The majority of udder growth occurred between the last 30 days of pregnancy and the first 10 days of lactation.

During gestation and lactation, an alteration of mammary gland tissue composition occurs, as well as for the first 15 days of gestation, where parenchyma fatty tissue proportion decreases and fluid-rich tissue increases [35]. Such alterations in parenchyma composition can be directly related to the increment of milk secretion and fluid accumulation in the gland [35]. Thereafter, mammary gland composition remains constant throughout late gestation and the entire lactation period. As the majority of udder growth occurs during early lactation, a reduction of mammary gland volume was detected during mid-lactation [37]. Reduction of the udder volume during the stage of lactation was reported as correlated both to parities and the mammary gland volume at the onset of lactation [37]. For example, goats with twins had more voluminous udder (+40%) than those with simples [38].

4. Review on the milk potentialities of goats and sheep raised in Maghreb and Mediterranean areas

Sheep and goats are mainly elevated for meat production in many regions of the Maghreb areas because of the harsh environments prevailing. The most of breeds have not been selected for milk yield, at the exception of the Sicilo-Sarde, where its nucleus was in Tunisia [10]. Thus, the official statistics reveal that the integrated dairy chains rely mainly on cattle milk, given that milk from non-cattle species (small ruminants and camel) represents respectively 21.3, 5.1 and 3.7% of the overall output in Algeria, Morocco and Tunisia [11] and its industrial processing remains rather weak.

After an increase by 18.7% (1997–2007), the goat population reached more than 1.5 million heads in Tunisia [66]. Such growth has been followed by the increase of production. Almost 60% of the Tunisian goats are located in the centre and in the south, reared in semi-intensive oasis systems, in small herds [70, 71]. Noting that the native goat from Tunisia is named Arbi to distinguish it from imported breeds, and it is well adapted to the natural environment of country [67]. Meat remains the major production of Arbi goats from Tunisia but also milk is produced only for home consumption. Under semi-arid conditions in the South, milk potential of the Arbi goat ranged from 1.14 to 0.69 kg/goat/day in the first 6 weeks of lactation, for females suckling singles, while those suckling twins produced 0.86–1.64 kg/goat/day [36]. Similarly, milk production ranged from 1.2 to 0.75 kg/goat/day [74] in the north where goats are reared in extensive mixed farming systems [69], together with sheep and cows. Genetic improvement schemes and biodiversity conservation strategies are currently studied in Tunisia for the native goat [68]. In some cases, the genetic capacities represent a serious restriction to improve goat production, especially for milk [72]. Failures in livestock improvement programs (national and international projects) did happen and animal productivity has remained poor.

When considering breed sheep, the only African dairy one is the Sicilo-Sarde as its milk is mostly used for cheese manufacturing. The population of Sicilo-Sarde is estimated at approximately 20,000 animals concentrated in northern Tunisia [62]. This breed was originated in the early twentieth century by crossing the Sarda and the Comisana dairy breeds, from Sardinia and Sicily (Italy), respectively, to produce sheep cheese for the Italian community.

The lactation curves have wide possibilities of applications, especially in genetic evaluation [75], ratio formulation and economic evaluation of different breeding practices [76, 77]. The prediction of yield peak is indispensable for the arrangement of feed orientation permitting and to cover the requirement of animal, reduce the cost and maintain such peak yield for as long as possible [78, 79].

A recent study taken in the Sicilo-Sarde breed [80] showed an average of daily milk production of 0.46 L with a high variation between 0.10 and 2.40 L and a milk period of 132.8 days. This study shows also a similar milking-only length (139 ± 47 days) and suckling length (104 ± 22 days) to previous reports [81]. Sicilo-Sarde ewes have a low production performances comparatively to Lacaune breed (on average 290 L of milk during 165 days) [82] and Sarda breed (on average 203 L and 162 days for milk yield and milking period) [82]. Such difference can be explained by a random crossing with other breeds which could threaten the genetic integrity and partly explains the low milking performances of Sicilo-Sarde breed [36].

Rural management farm of the Tunisian Sicilo-Sarde sheep marked a long suckling interval (3–4 months) and long lambing period (August to October) [63]. Therefore, the weaning practice applied depends on the selling price of milk. If prices are high, early weaning is practiced; if not milk is reserved only for lamb suckling. Several attempts have been undertaken during recent years in order to rehabilitate the dairy sheep sector in Tunisia [62], as well as to increase the combined member's herd size from 10,000 to 30,000 Female Units and to improve the milk yield/ewe/year from 90 to 150 L [64]. Several considerations were taken to encourage the association of breeders, control the performance and to enhance the pasture productivity throughout many programs managed by the OEP (Office of Livestock and Pastures) like as via the training and information days [65].

Udder volume evaluated for Sicilo-Sarde [52] is similar to that of Manchega dairy ewes, but smaller than that of Lacaune and Istrian dairy crossbreed ewes [50, 56]. Positive correlations were observed between estimated daily milk yield and both udder depth and udder volume in Sicilo-Sarde [45, 52]. Cisternal area also positively correlated with total milk yield, indicating that ultrasonography could be used for predicting milk yield in Sicilo-Sarde ewes. Milking lag time and total milking time reported in Sicilo-Sarde [52] were shorter than those reported in Manchega dairy ewes [61], probably due to differences between breeds in milk yield. Similarly, positive correlations were also observed between daily milk yield and both udder depth and udder volume [45, 52]. Sicilo-Sarde ewes showed adequate udder morphology for machine milking. The percentage of cisternal milk in this breed (54%) is similar to values reported in Manchega ewes [53, 54] and East Friesian crossbred dairy ewes [60], but lower than in Lacaune (74–77%) [53, 54] and Sarda ewes (82%) [58]. A medium correlation ($r = 0.69$) was reported between cisternal area and cisternal milk at 8 h after milking in Sicilo-Sarde, as a consequence of a multilocular structure, being lower than correlations reported in Manchega ewes [53, 54], dairy goats [57], and dairy cows [59]. According to previous observations on Mediterranean dairy sheep [46], Sicilo-Sarde dairy ewes are characterized by medium size udders and favourable teat position. This breed showed adequate udder morphology for machine milking [52]. Sicilo-Sarde dairy ewes are also characterized by favourable teat position [46, 52], and can be grouped as medium-cisterned ewes [52].

The seasonality of milk production characterizes the major dairy sheep industry. Nevertheless, an intensive breeding system of dairy ewes has practiced in some countries of the Mediterranean basin, for examples, those in Israel and Spain, where two breeds are mainly elevated: the Assaf and Awassi [39, 40]. In such managements based on the keeping indoors of ewes during the year and an accelerated lambing rhythm is applied with several mating/insemination season. Milking practice starts from the first day of the lactation's ewe and lambs are immediately adapted to an artificial rearing unit after their birth. Such practice of milking regime is exclusive for dairy ewe. For the Assaf ewes, few conceptions occur in early spring (February and March), which is considered an "out of season" period as it commonly results in a low conception rate and few lambs being born in summer (July and August) [41, 42].

In Italy, production of ewe milk is strongly seasonal and this seasonal production system involves most of the dairy breeds. However, under certain environmental conditions, certain breeds are able to mate during different periods. A weaning drop of milk potential is generally detected in dairy breeds [43, 44] and can be explained by the partial disappearance of the stimulus produced by the lamb when suckling. The decrease of milk production after weaning varied from 30 to 40% in the Lacaune, Préalpes du Sud, and Awassi breeds [45]. Likewise, it was observed [47] that the decrease of milk production at weaning (23–35%) may be explicated by a drop of emptying frequency (20–25%) and probably by a separation of mother-kid (3–7%). Sicilo-Sarde ewes are characterized by reduced teats in comparison with Manchega, Lacaune, Istrian dairy crossbreed and Bergamasca ewes [48–50, 55]. No significant correlations exist between teat length and milk production [48, 50]. The teat diameter of Sicilo-Sarde, measured at the medium point of the teat, was smaller than values reported in French Rouge de l'Ouest ewes [51]. Teat angle exists in of Sicilo-Sarde similarly to those in Manchega and Istrian dairy crossbreed ewes [50, 56], but with great values than those observed in French Rouge de l'Ouest ewes (26.5°) [51]. Udder volume calculated for Sicilo-Sarde is similar to that of Manchega dairy ewes, but smaller than that of Lacaune and Istrian dairy crossbreed ewes [50, 56].

5. Conclusions

The productive potential of Maghreb goats and sheep has to be considered taking into account the environmental factors and other genetic and epigenetic factors which may affect milk and lipid content.

Programs reserved to smallholder units must be urgently developed, considering their intervention as the main actors in dairy farming, and this to promote the overall farm performances, to adopt an efficiency strategy of irrigation, fodder biomass yield and its conversion to animal protein (milk and meat) and orient such farms towards dairy specialized producers.

In addition, further efforts are desirable for the promotion and diversification of income sources in dairy production chains. This will have a direct result with the development of good governance to anticipate and overcome future collective challenges: transparent appreciation and remuneration of milk quality, regular negotiations between stakeholders (smallholders, collection cooperatives and milk processors). Considering the increasing price of animal feed products on the world markets, the promotion of self-sustaining milk production chains will be indispensable.

Otherwise, preserving some small ruminant breeds of Maghreb again degradation or extinction requires an urgent establishment of breeding program simultaneously with an awareness of farmers through the action of associations that should

be supported over some subsidies especially livestock feed, programming technical training for farmers, milk collectors and the creation of other industrial processing units.

Understanding the lactate processes as well as to underline the mammary gland morphological patterns and physiology traits as well as milk potentialities of the sheep and goats may improve dairy production efficiency and would be basis to better define selection indices for dairy sheep and goats breeds under a dual purpose production system in the Maghreb areas; milk and meat.

Conflict of interest

We declare that we did not have any "conflict of interest" declaration.

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