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Review article

Effect of milking frequency and lactation length on yield and milk composition in goats

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ABSTRACT

The level of individual milk output per dam is a crucial element in the economic survival of any dairy enterprise. A profitable goat dairy enterprise should aim at maximazation of milk output per dam or optimizing the overall milk output from the flock. The present discussion explores the potential use of milking frequency as a management tool available for goat dairy farmers in manipulation of milk yield per dam and its implication for mammary functioning and its influence in enhancing metabolic activities in milk secretion. The influence of lactation length on yield and milk composition is also discussed. Lactation length and milking frequency are some of factors which have been implicated in influencing yield and milk composition. Different milking frequencies in different management systems have been studied with different results observed in their influences on yield and milk composition. There are different adaptive responses of the mammary gland of different animal species to extended milking frequencies and lactation length in different systems of management. The lactation length records can facilitate the allocation of resources such as feed supplies both for individual doe and the flock. From the discussion milking frequency and lactation length account for some of the variation in milk yield and composition, therefore adjustment of dairy records for lactation length is essential for accurate selection of dairy animals in a flock.

The feature of once daily milking is that it reduces milk yield, depending on stage of lactation, breed and parity. However, with the labour costs being recognized as one of the highest contributors to a dairy enterprise daily expense, it is suffice to suggest that the cost implications related to once daily milking can not be ignored. In goats milked twice daily, but increasing milking frequency to three times a day or even more often increase goat milk yield.

1. Introduction

The importance of goats as providers around the world of essential dairy products has been discussed and documented in many recent proceedings of national and international conferences (Gruner and Chabert, 2000; Boyazoglu and Morand-Fehr, 2001; Haenlein and Fahmy, 1999; Haenlein, 1992, 2001; Morand-Fehr and Bovazoglu, 1999). There has been a phenomenal increase in dairy goat numbers around the world in recent years (FAO, 2002; Park and Haenlein, 2006). Of the total world population of goats, 94 percent are said to be found in developing countries, supplying 73 percent of the milk produced by goats (Devendra, 1987). In terms of goat breeds, some have a greater potential for milk production and are known to be kept primarily for this purpose (Gall 1975). The composition and yields of goat milk and factors affecting them have been previously reported from various parts of the world (Anifantakis and Kandarakis, 1980; Jenness, 1980; Loewenstein, 1982; Middleton and Fitz-gerald, 1981; Morand-Fehr, et al., 1982; Olmedo et al., 1979; Parkash and Jenness, 1968). Some of the factors affecting goat milk yield and composition include breed, stage of lactation, season of kidding, nutrition, parity, lactation length and milking frequency (Kuchtik et al., 2008; Zehra, et al., 2007; Oravcova et al., 2006, 2007;Pavić et al., 2002; Erdman and Varner, 1995;.). The present discussion explores the potential use of milking frequency as a management tool available for goat dairy farmers in manipulation of milk yield per dam and its implication for mammary functioning and its influence in enhancing metabolic activities in milk secrection. It will also highlight the importance of lactation length on goat milk yield and composition.

Frequency of milking is of great importance in determining milk yield in dairy animals and is the main factor regulating milk yield and quality if feeding, welfare, health, and environmental conditions are adequate. Regular removal of milk from the mammary gland is critical to maintaining milk secretion (Wall and McFadden, 2011), which suggests that frequency of milking can be a important management tool which could be manipulated to improve the overal milk output from a flock. Increasing or decreasing milking frequency impacts the processes involved in mammary functioning. Reduction in milking frequency is much less practiced, however, reduced milking frequency in goats can be strategically adopted during certain stages of lactation period where less emphasis is tagereted on individual dam's milk output. Comparison of frequent milking of once daily and twice daily, a small compensatory increase in milk yield in the twice daily glands was observed (Stelwagen and Knight, 1997). The reason for this increase was related to greater sudden substrate availability to the twice daily milking. However, such compensatory effects could be accounted for by expressing the yield as the relative milk yield quotient (Linzell and Peaker, 1971), allowing the extent of the local, intramammary effects of altered milking frequency on milk yield to be determined.

Milk yields increased up to the end of two months and then started to decline with an average lactation length of 260 days (Hassan et al., 2010). The highest milk yield in the crossbred and Damascus goats was attained in the fourth and fifth months of lactation, respectively. The close association between milk yield and lactation length has sometimes been taken as an indication that yield records should be adjusted for length of lactation. A correction procedure can be developed by estimating the regression of milk yield on lactation length in a sample of data and using this to construct a prediction equation.

2. Influence of milking frequency on milk yield and composition

Frequency of milking is of great importance in determining milk yield in dairy animals and is the main factor regulating milk yield and quality if feeding, welfare, health, and environmental conditions are adequate. Howver,

an attempt to provide a detailed summary of the complex regulatory processes underlying the changes in milk production induced by altering milking frequency is nearly impossible. However, Knight et al. (1988) proposed to distinguish three phases through which the mammary gland evolves in adapting to increased or decreased milking frequency, an acute phase (one to several days), a short to medium-term phase (days to weeks), and a long-term phase of adaptation (weeks to months). Milking dairy goats have been shown to have an increase in milk yield either by milking goats once a day throughout lactation resulted in a 6–35% drop in milk yield compared to milking them twice a day (Salama et al. 2003). There are different adaptive responses of the mammary gland of different animal species to extended milking intervals in different systems of management (Marnet, and Komara, 2008) and goats seem to adapt to once-daily milking better than cows. Additionally, goats with higher production levels demonstrate a lower reduction in milk yield. Once daily milking of dairy cows is practiced in some countries either in early lactation to reduce metabolic stress or in late lactation to improve quality of farming life (Davis et al., 1999). Whatever the reason, dairy farmers try to keep the intervals between milkings to similar lengths of time. High-producing cows and heifers have been shown to give four to seven percent less milk if milking intervals were 16 and 8 hours (Bath et al. 1985). Compared with twice daily milking, once daily milking reduced milk yield by 6 to 35% in dairy goats (Mocquot, 1978; Capote et al., 1999). The wide variation in yield losses during once daily milking reported by other authors may be due to differences in breed, lactation stage, level of production, duration of once milking and individual characteristics (Salama et al., 2003). It is well known that a greater frequency of milking increases milk production in goats, and conversely, that a build up of milk in the udder will reduce milk yield. This is due to the fact that changes in milking frequency influenced mammary blood flow, as well as mammary cell number and activity, and this response was regulated locally within the mammary gland (Wall and McFadden, 2011). Mocquot, (1978) observed a reduction in milk yield as the number of times a goat is milked per day is reduced. When goats were milked once a day the resultant milk yield was reduced by one third and where one milking was omitted yield was reduced by 5 percent. This was attributed to the fact that secretion rate increased when milk was removed more frequently, as for example with thrice daily milking, especially for those goats that store a relatively high proportion of their milk in the alveoli compared to cisternal volume (Knight et al. 1994). Increasing milking frequency to four times daily even for a short time (21 days), increased overall milk yield throughout lactation (Koyuncuand Pala, 2008).

Wall and McFadden, (2007) concluded that the increase in milk yield associated with increased milking frequency is regulated locally within the mammary gland. Goats milked once daily were not adversely affected by intensive management system, with no specific vocalization or increase in agitation at the time when milking was suppressed (Marnet et al., 2005), however, relative to controls, the milk fat lipolysis was significantly less in goats under once-daily milking management. The reduction of fat concentration for these goats that were only milked once daily could be due to lack of adaptation to level of feeding (e.g., too high concentrate quantity or acidosis) and/or milk ejection could have been affected slightly by the possible stress of the animals, resulting in retention of fat in the alveolar lumen. This means high-yielding goats could have a different regulation or mammary strategy for use of the blood precursors used for synthesis of milk fat that could explain the lack of increase or the decrease in fat concentration observed. Baumgard et al., (2000) cited that this scenarion could be due to a greater sensitivity to or a greater production of the precursor, *trans*10 C18,1, which is known to be an inhibitor of milk fat synthesis in the mammary glands of cows with low fat milk syndrome during the peripartum period. Once daily milking in goats moderately reduced milk yield without negative effects on milk composition and udder health. Since milk of dairy goats milked once contained more fat without significant increases in somatic cell count, reduced revenue due to lower milk yield could be partially offset if payment for milk was based on milk quality (Salam et al., 2003). Hence, the rate at which milk constituency or components change may be influenced by farm management practices, such as feeding, photoperiod, hormonal treatment (e.g., bovine somatotropin), and milking frequency (Stelwagen, 2001). The effects of increasing and decreasing milking frequency on mammary functioning were discussed, with emphasis on functional changes in the once-daily milked gland with regard to processes such as changing cell number or activity, feedback inhibition, tight junction leakiness, apoptosis, and cisternalalveolar milk storage. The relationship between cisternal capacity and milk yield loss during once-daily milking was also confirmed by Knight and Dewhurst (1994), Stelwagen and Knight (1997), and Davis et al. (1998). Goats have a higher proportion of milk in their cistern than other species that makes them have a greater capacity to continue to produce milk during extended milking intervals due to this anatomical characteristic (Marnet and Komara, 2008). However, the percentage of cisternal volume relative to total udder volume does not seem to explain this difference in ability to not suffer milk yield loss with longer milking frequencies among goats This may

indicate that another mechanism of regulation of milk synthesis is established in goats before the udder and their cisterns are completely full.

There is milk yield and species differences in hourly fat secretion rates which may be a result of the plateau observed in the transfer of fat from alveolar milk to cisternal milk during the longer milking intervals, resulting in an accumulation of fat in the alveolar compartment (McKusick et al., 2002). Abdel-Salam et al., (2000) found that lactation length (days) were different between the Damascus, Barkey goat breeds and their crosses in the desert of Egypt. With goats, there is only a limited variation in milk quality of the milk produced due to frequency of milking, but ewes and cows show a significant enrichment of milk constituents, especially in fat. This indicates some differences in the regulation of lactose, protein, and fat synthesis depending on the duration of the milking. This knowledge may be put into good use in providing interesting models for physiological studies on milk secretion and synthesis regulation (Marnet, P.G., Komara, M. 2008). It is possible that uneven milking intervals will have less effect in goats than in cows (Mowlem 1988), because goats have a greater proportion of cisternal milk than cows (Dewhurst & Knight 1993; 1994). It may be necessary to adjust milk records either for long intervals or for increased milking frequency if these are factors in the management system. It should be acknowledged that milk yield is a function of the number of mammary secretory cells and their metabolic activities, are bound to change during the course of lactation. The mechanisms underlying the response of the mammary gland to milk removal are not well understood; however, experiments in ruminants have shown that changes in the frequency of milk removal can influence mammary cell number and activity (Hadsell et al., 2007; Wall and McFadden, 2008). The rate of these changes are potentially influenced by various farm management practices which include milking frequency. Therefore, milking frequencey can be one of the management tools which can be manipulated at any time during the course of lactation to maximize milk production. Different milking intervals can be applicable before or after peak lactation to increase milk yield, and perhaps slow down the rate of postpeak decline in milk yield, and have implication for the promotion of mammary involution at the end of late lactation into near drying-off. The stimulus of increased milking frequency for a short period (i.e., 2 to 3 wk) during early lactation is sufficient to increase milk production through late lactation, long after twice milking is resumed (Wall and McFadden, 2008). This indicates that the mammary gland is especially sensitive during early lactation to the demands of the offspring, which influence the shape of the lactation curve.

Generally cows are milked twice daily, but increasing milking frequency to three times a day or even more often increases milk yield by 10 to 20% (Erdman and Varner, 1995; Jurjanz et al., 1993; Van der Iest and Hilerton, 1989). There is evidence that long-term three times milking increased the amount of mammary parenchyma in goats (Henderson et al., 1985). In addition, it was discovered that increased milking frequency increased milking frequency during early lactation stimulated an increase in milk production that partially persisted through late lactation, indicating long-term effects on mammary function. Traditionally this was assumed to be a result of a build up of intra-mammary pressure (Schmidt & Van Vleck 1974), but more recent research has indicated that it is the effect of a fraction of whey protein (Wilde et al., 1987) which affects the proliferation and loss of secretory cells. The fact that in most studies mammary cell activity has been measured after a relatively short treatment period, weeks rather than months, the conclusion on mammary cell activity may be misleading. Interestingly, there is evidence from goats to suggest that during long-term (i.e., months) thrice milking the increased cellular activity is not maintained, despite a persistently higher milk yield (Wilde et al., 1985). This implies that over the longer term, the higher milk yield is maintained by factors other than increased cellular activity. Stelwagen, (2001) in his study comparing twice daily milking, milking three times a day and more often (robotic milking) increased milk yield by 18%, whereas once-daily milking decreases milk output by 20%. This was the background that frequent milking is practiced more often than once daily, however, the once-daily milked gland provides an excellent model to study functional changes related to milking frequency. Travers and Barber (1993) showed that in goats increasing milking frequency from twice to thrice increased mammary cell activity. Both the amount of ribonucleac acid per cell (general cell activity) and the activities acetyl CoA carboxylase and fatty acid synthethase (specific cell activity) were increased. Similar studies have demonstrated that increased enzyme activity with thrice milking in goats (Wilde et al., 1985, 1987; Wilde and Knight, 1990).The milking system with a strict milking interval of 16 h was reported having the physiological limits acceptable by the mammary gland (Davis et al., 1999). Suckling between the 24-h milking intervals seemed to be a good solution to avoid the negative impact of milk accumulating in the gland on milk yield. This practice is reasonable, easy to implement, and well accepted by the animal, as well by defenders of their welfare, because this milking regimen more closely mimics the natural maternal behavioral routines of the animals (Marnet and Komara, 2008).

3. Influence of lactation length on milk yield and composition

Extended lactation did not significantly decrease milk yield, but increased milk components, and may be a useful strategy for reducing metabolic stress in early lactation and for simplifying herd management in dairy goats (Salama, et al., 2005). With respect to lactation length and milk yield, differences from other breeds, such as Saanen and Toggenburg, may have been due to diet, environmental conditions, breed, litter size, lactation number, and kidding season (Mourad, 2001; Crepaldi, et al., 1999). The longer lactation length might be due to the effect of continuous suckling by calf. In dairy cows, longer suckling period inhibits the growth of ovarian follicle and prolongs the period of anoestrus, thereby lengthening lactation length (Chandler and Robinson 1974). Length of lactation had significant effect on initial milk yield and rate of increase up to peak but peak yield, time to peak, time to peak yield in weeks and persistency were not affected by lactation length (Waheed and Khan, 2013).The changes in short-chain FFAs in milk were not as great as those of long-chain fatty acids, throughout lactation. With the progression of lactation, changes in grassland and milk volume did not affect short-chain FFAs. Wijesundera et al. (2001) reported that the content of short chain fatty acids in cow's milk was unaffected by lactation period. Similar results were obtained by Kondyli and Katsiari (2002) for native Greek goat's milk. In addition to lactation duration, there was no signifi cant influence was found of birth type, number of kids born or reared on the qualitative and quantitative parameters of milk yield in goats. Milk yields increased up to the end of two months and then started to decline with an average lactation length of 260 days (Hassan et al., 2010). Goats that produced twins yielded more milk and had longer lactation (Carnicella et al., 2008). Average lactation length of different breeds differed significantly breeds (Zehra, et al., 2007) and the effect of lactation period on milk yield was probably due to physiological changes in the number and activity of secretory cells within the mammary gland (Al-Khouri (1996) and Mourad (2001) studies in Alpine goats. The highest milk yield in the crossbred and Damascus goats was attained in the fourth and fifth months of lactation, respectively. The milk yield in both groups gradually decreased from August towards drying-off. Some goat milk producers breed high yielding goats only every second year, to ensure continuity of milk production, with a resulting lactation of up to 22 months. However, the more usual practice is to breed them annually, resulting in a lactation of ten months and a dry period of two months. Non-dairy breeds may not have a lactation this long, and then the dry period would be longer than two months (Devendra & Burns 1983). As with dairy cattle, it appears that a dry period is essential before a new lactation, to allow time for regeneration of secretory tissue. Short dry periods reduce subsequent milk yields (Schmidt & Van Vleck 1974). However, one experiment (with only four goats) showed no reduction of milk yield after the dry period was omitted, comparing milk production between halves of the udder (Fowler et al.1991).

4. Implications

It is assumed that in dairy goats, the compliancy of the mammary gland mechanism and regulation of tight junction impermeability, could be involved in milk secretion regulation and, thus, could become new targets for genetic selection of animals better adapted to accept extended milking intervals. As a result, milking frequency can have a significant impact on milk yield in goat when viewed from the producer's viewpoint, the fact remains that the mammary gland in high producing dams is highly resilient and continues lactating successfully with biologically minor decreases in milk yield even under conditions radically different from modern dairy management practices. Lactation length and frequency of milking are very important to milk yield and composition, which need to be controlled or adjusted when comparing animals' individual productivity. This discussion provides an important perspective on the influnce of lactation length and milking frequency on the overall milk production in goats, hence evaluation of these is generally aimed at increasing milk production in goats. Anatomical and physiological characteristics of lactating dams in different animal species, in terms of cisternal vs. alveolar volumes within the mammary glands, could contribute to different abilities in adaptation to different milking systems. The effect of milking frequency varies depending on the species, breed, and genetic merit of animals used. In concern with milk production, milk yield as in other well-recognized quantitative traits in animal science is influenced by genetic and non-genetic factors. In dairy goat, investigation of the relationship between lactation length and milk yield as a quantitative trait enables breeders to obtain beneficial clues not only for accomplishing on the subject of selection of superior goats and but also for developing better selection strategies on milk yield per goat. The close association between milk yield and lactation length has sometimes been taken as an indication that yield records should be adjusted for length of lactation. A correction procedure can be developed by estimating the regression

of milk yield on lactation length in a sample of data and using this to construct a prediction equation. On the other hand, although milking frequency is a tool necessary to manipulate milk production, a consideration of other non genetic factors may be even more effective in improving the overall milk yield and composition.

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