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REVIEW

Invited Review: Current areas of research of feeding practices for lactating goats[1]

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ABSTRACT

Dietary concentrate level, forage quality, and production system can have a great effect on tissue loss and gain by lactating goats in addition to milk yield and composition. Opportunities for enhanced performance with high concentrate levels are greater in early than late lactation, with high milk production potential, although there might be an advantage in efficiency of energy use in late lactation when tissue is often replenished. Effects of by-product and alternative feedstuffs on conditions such as ruminal methane emission, milk fat content and fatty acid (FA) composition, and antioxidant status depend on major and minor constituents and what they are substituted for. Research on minor dietary ingredients such as probiotics and plant secondary metabolites is likely to increase with decreased use of synthetic antimicrobials, although specific components responsible for effects are sometimes unclear. In addition to the FA profile of feedstuffs, conditions including dietary concentrate level, supplemental FA sources, and levels of plant secondary metabolites can influence bioactive ruminal biohydrogenation intermediates that decrease de novo FA synthesis in the mammary gland. Supplementation with sources of conjugated linoleic acid has been studied, but use is not common, probably because of less change in milk fat content and FA composition compared with cattle, different considerations regarding tissue mobilization in early lactation with appropriate feeding management practices, and limited or no benefit from low-fat milk. However, inclusion of moderate dietary levels of oils and other fat sources for purposes such as increased energy density, improved palatability, and decreased dustiness is widespread.

Key words: feeding, goats, lactation, nutrition

INTRODUCTION

There are many topics currently receiving research attention regarding the nutrition and feeding of dairy goats, with no single area that can be easily justified as being much more important than others. Therefore, to identify topics and studies to be reviewed, a literature search with ScienceDirect was conducted with key words of dairy, goat, feeding, and nutrition. Articles published in 2010 to 2015 were selected and categorized as noted below.

- Production system
- Dietary concentrate and fiber levels
- By-product and alternative feedstuffs
- Minor dietary ingredients and plant secondary metabolites
- Dietary inclusion of fatty acids
  - Species differences
  - Conjugated linoleic acid supplementation
  - Fat and oil supplementation

The 3 subtopics under the area of "Dietary inclusion of fatty acids" reflect considerable attention being given to modifying the fatty acid (**FA**) composition of goat milk. Moreover, even in studies where this is not the primary focal point, the FA composition of milk has been frequently determined.

The objective of this paper is to review current research of the nutrition and feeding of dairy goats. This will be achieved through brief synopses of publications selected from the aforementioned literature search and a few less recent articles to address the broad array of factors affecting feeding practices for dairy goats under the correspondingly wide spectrum of conditions under which they are raised around the world.

PRODUCTION SYSTEM

Dairy goat production systems can be grossly categorized as confinement, grazing or browsing, or a mixture, although an alternate classification

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used by some is intensive, extensive, and semi-intensive or semi-extensive. One of the most significant differences between production based on grazing or browsing and that based on confinement is the amount of energy used for activity (Goetsch and Gipson, 2014). Other important differences include levels of FA in feedstuffs and other factors influencing conditions in the rumen and mammary gland that affect the FA profile in milk.

The study of Kharrat and Bocquier (2010) provides an example of a mixed production system. The importance of initial body condition at kidding to allow milk production in early lactation from tissue mobilization when grazing natural rangeland was evident. Dual-purpose Baladi goats grazed mountain natural rangeland in early lactation and agricultural pasture in mid-lactation. One-half of the goats continued to graze agricultural pasture in late lactation, and others were stall fed a high quality diet. Tissue replenishment in late lactation was greater for stall-fed goats to minimize need for tissue gain in the dry period, and milk production was slightly greater as well. Presumably, these differences were mostly functions of ones in quality of the diet ingested and the lesser amount of energy expended by stall-fed goats for activity.

Production system can have marked effects on periods of tissue loss and gain throughout the production cycle in addition to affecting milk yield and composition. In this regard, Dønnem et al. (2011) conducted a study with different forage qualities partially to address the occurrence of high levels of hydrolysis of triglycerides into FFA causing off-flavor in milk of Norwegian dairy goats experiencing appreciable body fat mobilization, particularly when on natural summer pasture. However, this experiment was conducted in confinement from 3 to 19 wk after kidding. Norwegian does consumed ad libitum 2 grass silages cut at different stages of maturity and were supplemented with low or normal levels of concentrate (i.e., approximately 0.5 and 1.0 kg of DM). Organic matter digestibility of the diets was relatively high, averaging 77 and 67% for the high- and low-quality silages, respectively. In contrast to some other studies such as those by Ngwa et al. (2009) and Kharrat and Bocquier (2010) in which body fat was mobilized in early lactation and replenished later, only with the least quality diet was fat mobilized during this period, though positive change in BW occurred (i.e., 32 g/d). It was concluded that high-quality diets in confinement can prevent tissue mobilization throughout lactation, although with questionable direct relevance to pasture conditions and animals expending considerable energy for grazing. Furthermore, a diet such as the one with the highest quality silage and level of concentrate may not be most appropriate for feeding throughout a large portion of lactation such as in this study. For example, it appeared that initial adipose content of the whole body was approximately 15.8% for all does based on computer tomography. After 16 wk the fat level for does on the highest quality diet rose to approximately 22.5%. Based on the relationship Ngwa et al. (2007) established between BCS and whole body fat concentration with meat goats, BCS increased from 2.8 to 3.7, with the latter value perhaps indicative of excessive fatness. Conversely, more appropriate diets fed continuously this long in early through mid-lactation might be considered those with the higher quality silage and low level of concentrate or vice versa, for which average whole body fat concentration at the end of the study was approximately 18.4 and 15.3%, corresponding to BCS of 3.1 and 2.7, respectively. Conversely, the whole body fat level and BCS of does consuming the diet with the low-quality forage and low level of concentrate at the end of the experiment were 9.8% and 2.0, respectively.

In addition to unique aspects of confinement and grazing or browsing production systems, there is immense variation in how dairy goats in the latter systems are managed. Iussig et al. (2015) addressed some major considerations with Camosciata goats of Italy by determining diet composition in goats on open grassland versus grazeable forestland. Though botanical composition of herbage vegetation available was markedly different between the 2 areas, gross indicators of quality of the diet selected were similar. Vegetation ingested on grazeable forestland was greater in linolenic acid and phenolic compounds, and correspondingly, milk produced was greater in PUFA (3.05 vs. 2.61%; $P = 0.06$), total n-3 FA (0.85 vs. 0.61%; $P = 0.06$), and total conjugated linolenic acids (**CLA**; 0.52 vs. 0.38%; $P \leq 0.05$). However, neither an atherogenicity nor thrombogenicity index was affected. Phenolic compounds consumed in the forestland area did not adversely affect ruminal microbial activity based on branched-chain FA levels in milk, but rather the human health attributes of milk from goats on forestland primarily reflected differences in the FA profile of plants consumed. Such findings have relevance to cut-and-carry production systems or supplementation programs involving harvest of browse plant species or leaves of trees such as multipurpose legumes. Similarly, Tudisco et al. (2010) found a different profile of FA in milk from goats raised in confinement and in an organic production system (e.g., 3.6 vs. 4.5% PUFA; 17.1 vs. 19.1% oleic acid, 2.1 vs. 2.8% linoleic acid, and 0.6 vs. 0.8% linolenic acid). This appeared to be primarily because of different levels of FA in alfalfa consumed by confined goats and in pasture forage grazed by goats in the organic system (24.9 vs. 18.1% SFA; 63.1 vs. 77.0% PUFA; 16.8 vs. 27.2% linoleic acid, and 35.7 vs. 43.3% linolenic acid).

DIETARY CONCENTRATE AND FIBER LEVELS

Levels of feedstuffs categorized as concentrate versus forage or roughage in ruminant diets have been extensively studied throughout the years. However, because of immense variability in the nature of feedstuffs within each class, inclusive of interactions