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Effect of Nutrition on Fiber and Follicle Development in Goats and Sheep

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Importance of Fiber Production

- Natural animal fibers such as wool, mohair and cashmere have been used for years for clothing, upholstery and fire retardant fabric in the aerospace industry. Mohair and cashmere are known for luxury clothing and for the fashion industry.
- Wool has been important for keeping mankind warm for centuries.
Importance of Fiber Production

• Synthetics and change in fashion and consumer values have reduced demand for natural animal fibers, but nonetheless they are still important for luxury garments.
• Mohair is unsurpassed as a luxury fiber with its luster.
US Fiber Production

• The US was once a leading fiber producer during World War, but two, but since then the industry has been in decline.

• The fiber subsidy was repealed in the mid-90’s coinciding with a downturn in the mohair market prices which hit the industry with a double whammy.
US Fiber Production

- Sheep numbers have declined since World War two and so has wool production.
- Sheep numbers have declined by 50% in the last 20 years and are at 10% of World War two levels.
- Sheep numbers have declined throughout the world.
US Fiber Production

• Reasons for decline in sheep production:
  • Loss of labor since WWII
  • Loss of grazing permits in the West
  • Predator problems
  • Big farms do not have time for a sheep enterprise
  • Cancellation of wool act and subsidy
US Fiber Production

• The Boer goat was imported into the US in the mid 90’s distracting producers from mohair production.

• The cost of shearing increased and the availability of shearers decreased.
US Fiber Production

• The US has some of the best genetics for mohair production, a result of breeding goats for mohair production for a century.

• South Africa with its cheap labor and Australia are now the leading mohair producers.
Fiber Production

- Cashmere and mohair are produced by goats and wool by sheep.
- The effect of nutrition on the production of fiber tends to be unique to that fiber.
- China leads the world in cashmere and wool production.
Definition of Cashmere

- Cashmere is a fiber without medulla produced by secondary follicles less than 16 um diameter. It is preferred to be at least 20 mm long.
- It grows seasonally, summer and fall, unlike the continuous growth of wool or mohair.
- Cashmere is an undercoat produced by all goats, especially in cold areas as the goat lacks subcutaneous fat.
Cashmere

Fig. 11.1. Comparison of the organization of the secondary follicles (S) and primary follicles (P) in dairy and fibre goats. (Adapted from Millar, 1986.)
Energy for Cashmere Production

• A goat producing 280 g of cashmere with an 18% energetic efficiency requires one ounce of TDN or the energy in 2 ounces of hay/day or 1.5 ounces of grain per day.

• Energy restriction decreases body gain, cashmere production and cashmere fiber diameter slightly.
Energy for Cashmere Production

- Cashmere production is less affected by energy supply than protein supply.
- However, feeding 1.4 X maintenance energy maximized fiber production, coinciding with body weight gain and confounded by a greater body area producing cashmere.
Energy for Cashmere Production

- Feeding at 73% maintenance reduced cashmere production by 24% but reduced fiber diameter by only 2%.
- This was associated with body weight loss and maybe less body area for producing cashmere.
Energy for Cashmere Production

• Feeding at 80% of maintenance caused weight loss and delay in molting of about 1 month.

• Feeding at 120 and 200% of maintenance decreased the time to molting.
Protein for Cashmere Production

- Cashmere fiber and guard hair are composed of proteins belonging to the $\alpha$-keratin family. These proteins are high in sulphurated amino acids such as cystine and cysteine often supplied as a result of trans-sulfuration of methionine.
Protein for Cashmere Production

• Protein required per day is 6.4 grams (for 6 months of fiber growth) which could be supplied with 2 ounces of barley grain.

• Increasing protein increased guard hair growth, and cashmere diameter but not cashmere production due to reduced time to molt.
Protein for Cashmere Production

• Feeding protected proteins or protected amino acids did not improve cashmere production. The amount of protein required for cashmere growth of 300 g/season is less than a gram per day, easily provided from the existing circulating amino acid pool.
Protein for Cashmere Production

• The lack of response to protein or amino acid supplementation is thought to be due to the secondary follicles having fewer cells able to synthesize fiber protein and less intrinsic capacity for protein synthesis than mohair follicles.
Minerals for Cashmere Production

• The main mineral in cashmere is potassium which is due to the dried sweat in cashmere. Its daily production in the fleece is 60 mg/day which is 1-2% of the goat’s daily requirement for potassium.
Mohair Fiber

- Produced exclusively by Angora goats from secondary follicles. It has a diameter from 25-39 microns. In contrast to cashmere, it is produced throughout the year, although it grows slightly faster during the summer.
- Mohair is known for its feel, luster and strength. It grows from 2-5 cm per month or 5 to 17 g/day.
Mohair Fiber

• Luster is the ability to take color and to reflect that color that gives the fabric its beauty.
Mohair Fiber

- Grows from secondary follicles. The SF/PF ratio in kids is 2-3, associated with 24 micron fiber. As they grow, SF/PF will increase to 8-10 and fiber become coarser.
- Females have a higher density of follicles per square mm, finer fiber and lower percentage of medullated fibers than males.
Mohair Fiber

• Because of the high level of fiber production, there is competition for nutrients between milk (and possibly other productive functions) and fiber production, similar to that found in sheep.

• The NRC lists requirement of energy as 37.5 kcal/g of mohair production/day
Mohair Fiber

- Angora goats have been bred for one trait, mohair production to the exclusion of other bodily functions.

- Mohair has assumed a priority for nutrition over maintenance, reproduction and lactation. Angora goats will continue to produce fiber when they are starving to death.
Energy for Mohair Production

• In goats that are underfed, they lost weight, produced 15-40% less mohair and fiber was 2-3 microns finer. Supplemented goats gained weight, produced up to 100% more mohair which was 2-3 microns coarser. Any supplementation decision needs to consider a 5% discount for each micron coarser fiber.
Energy for Mohair Production

• Medullated fibers and kemp (defects of hollow fibers) were not affected by supplementation, but strongly affected by genetic factors and age of animal.

• Energy supplementation is necessary for animal welfare.

• Rumen buffers may be appropriate for grain supplementation.
Protein for Mohair Production

- Mohair production increased with supplementation up to 19% dietary CP.
- Mohair production increased 23% and fiber diameter was increased by 5%.
- The finest fiber diameter was achieved with a diet of 10.5% CP.
- NRC lists requirement for protein as 1.65 g of protein/g of mohair fiber produced.
Protein for Mohair Production

• In the summer when mohair growth is more rapid, a substantial increase in fiber growth can be obtained with diets containing large amounts of sulfur amino acids reaching the intestine.

• Protected methionine increased mohair production from a 10.7% CP diet.
Protein for Mohair Production

• Due to the competition for nutrients between mohair production, reproduction and lactation, it is critically important to provide sufficient protein to the animal during late gestation and lactation for successful reproductive outcomes.
Effect of Infused Amino Acids

• Infusion of methionine increased clean mohair yield (5.3%) and fiber diameter (2.5%) whereas lysine administration decreased fiber yield (9.2%) and fiber diameter (3.8%). However, mean fiber length was increased 21.7% by lysine infusion.
Minerals for Mohair Production

• Feed adequate levels of all minerals for growth and production of the goat.

• Sulfur is important because of the sulfur amino acids in mohair. Requirement for optimal growth is 0.267% of diet DM and a ratio of 7.2:1 between N and S.
Vitamins for Mohair Production

- A deficiency of vitamin A and phosphorus reduced activity of the follicles. Biotin is also important for follicular growth and vitality. Deficiency will cause loss of mohair. No studies on the effect of supplemental biotin on mohair production.
Wool

- Natural fiber of sheep grown from primary and secondary follicles.
- It is crimped, elastic and grows in staples.
- Growth is continuous throughout the year, but tends to grow faster in the summer.
- Diameter, strength and staple length are important quality parameters.
Wool

• A sudden severe reduction in food consumption brought about by things such as drought, snow cover, illness or lack of water can cause a reduction in fiber diameter, making the staple subject to breakage, causing tender wool.
Energy for Wool Production

- While a substantial amount of information confirms that increased feed intake increases wool production, it doesn’t identify protein or energy as the limitation.
- It has been calculated that the energy to synthesize wool amounts to 9% of the ewe maintenance requirement.
Energy for Wool Production

• Wool production can be increased with increased energy except at very low CP levels, but this is likely due to increasing microbial protein production.

• One study indicated that energy requirement for wool production was 10-15% of maintenance energy.
Protein for Wool Production

• Major limitation to wool growth is the amount and composition of amino acids available to wool follicles, the supply of sulfur containing amino acids cysteine and methionine and to a lesser extent lysine.
Protein for Wool Production

- Microbial protein alone is deficient in supplying the sulfur amino acids for maximal wool production. Rumen escape protein is likely to be advantageous. But it is important to supply sufficient energy to support a high level of microbial protein production.
Protein for Wool Production

• Cysteine and cystine are very important for wool growth because of their high content in the wool. The conversion of methionine to these amino acids is an important source. In addition, methionine plays a more specific role in stimulating wool growth.
Minerals for Wool Production

• Deficiencies of copper and zinc have been shown to substantially reduce wool growth and weaken fibers.

• Sulfur is necessary, as a component of sulfur containing amino acids.
Vitamins for Wool Production

- Vitamins have not been shown to restrict wool growth in adult sheep. Folic acid and Pyridoxine (Vitamin B-6) are especially important for wool production and are produced in the rumen.
Perinatal Nutrition

• It is important that the lamb be well fed so follicle development is not delayed so maximal wool production can be obtained.

• Poor prenatal (d 90) nutrition decreases number of skin follicles and continued poor nutrition to 16 wk of age will permanently depress lifetime production.
Conclusion

- Some producers are focused on nutritional tricks to maximize fiber production, but generally the major limitation on fiber production in the industry is inadequate nutrition.

- Next to nutrition, management, and probably worms are important limiters of fiber production.
Conclusion

• In general, most protein supplements which increase fiber growth are not economic. More important to provide sufficient ruminal fermentable energy and nitrogen so microbes can maximize their synthesis of protein.