BROILER LITTER IN RUMINANT DIETS - IMPLICATIONS FOR USE AS A LOW-COST BYPRODUCT FEEDSTUFF FOR GOATS

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Abstract

Use of byproducts in ruminant diets can decrease production costs and increase total production. Chemical and physical characteristics of byproduct feedstuffs and animal nutrient requirements determine most appropriate means of use. Broiler litter is high in ruminally degraded crude protein and moderate to low in available energy concentration; therefore, most efficient use is as a crude protein supplement with low-protein forages such as cereal grain residues. However, because of low cost, broiler litter is frequently included in diets at moderate to high levels. In this regard, dietary substitution of broiler litter moderate to high in digestibility for forage does not decrease digestible energy or organic matter intake since greater total intake compensates for relatively low digestibility of broiler litter. Optimal levels of forage in broiler litter-based diets for high digestible organic matter intake by growing steers may be slightly greater than required for proper rumen function. Primary factors restricting efficiency of use of broiler litter at high dietary levels and with animals having high nutrient requirements involve low available energy and ruminally undegraded protein levels. Pertaining to the latter limitation, ruminally undegraded protein concentration in feedstuffs high in ruminally degraded protein, such as soybean meal, can be increased by mixing with broiler litter before the heat treatment process of deep-stacking. Another potential novel use of unique conditions in the broiler litter deep-stack is in decreasing condensed tannin concentration in added substrates. In conclusion, besides an associated lessening of feedstuff expenses and increasing potential production with set resources, broiler litter inclusion in ruminant diets can improve sustainability of livestock and poultry production through bioresource recycling.

1. Introduction

There are many agricultural and industrial byproducts that can be used in livestock production systems throughout the world. Considerable research has been conducted to determine most appropriate uses of byproduct feedstuffs. Such work will likely continue and possibly expand in the future because of the wide array of byproducts available and differences among regions of the world in other available feedstuffs also fed to ruminants and preferred livestock products.

Knowledge of a number of factors is needed to determine suitable and optimal means of employing byproducts as dietary ingredients for ruminants. Among the most important is chemical composition, as affecting conditions in the rumen for fermenting microbes and nutrient absorption by the animal. Ultimately, activities of ruminal microbes, ruminal outflow of feedstuff components not altered by microbial actions, extent of absorption in the digestive tract, and nutrient use by the portal-drained viscera and liver determine energy and nutrients becoming available to peripheral tissues and being used for their maintenance and accretion. Also for consideration are physical properties, which along with chemical composition can affect palatability. Physical characteristics impact ease of practical field usage and possibly nutrients available to the periphery through effects on visceral tissue metabolism. Lastly, the occurrence and nature of prior exposure to and experience with byproducts may be relatively more important to acceptability for ingestion compared with conventional feedstuffs.
Aforementioned factors determining preferred uses of byproduct feedstuffs obviously must be considered in regards to costs, including the monetary expense for procurement and other inputs associated with actual field use such as labor, equipment, and facilities. The basis for evaluating costs of byproduct feedstuffs relates to the particular production scenario of employment. Major production setting conditions to be considered include other feedstuffs available now and in the future, biological type, production stage, and previous nutritional history of the animal, and desired responses in live gain or loss as well as reproductive performance. These factors dictate the most constraining nutritional condition at the particular time of interest, and it is in this context that specific byproduct feedstuffs should first be characterized. For example, with ruminants consuming cereal grain residue the supply of nitrogenous compounds for ruminal microbes, most importantly ammonia, is usually most limiting to absorption by the animal of both amino acids and energy-yielding substrates. Thus, byproduct value should be assessed as cost per unit of ruminally degraded nitrogen or crude protein (CP). But, if conditions such as basal diet composition or animal characteristics change, likewise the basis for assessing byproduct value or cost shifts. For example, with growing animals possessing greater energy requirements than when mature, digestibility of byproduct feedstuffs increases in relevance, as influencing both ruminal microbial protein and volatile fatty acid production. Hence, in this case cost assessment should probably be based on both ruminally degraded CP and an index of ruminally fermentable organic matter, such as total digestible nutrients (TDN). Such estimates can be most appropriately derived from some of the relatively new nutrient requirement models. However, in reality, for many production scenarios an accurate determination of costs or value of available byproducts would not require complex models but can rather be simply acquired through reasonable knowledge of byproduct composition and animal nutrient requirements.

It is not the intent of this paper nor would it be possible with time and space constraints to adequately address all of the above considerations for the multitude of byproduct feeding scenarios dealt with around the world. Hence, some research findings, primarily from the US, concerning feeding considerations for one specific agricultural byproduct will be highlighted, with the intent that a portion of this information can be applied to other byproduct feedstuffs in various regions of the world. Furthermore, although outlined research with this byproduct, broiler litter, is with cattle, based on experimentation currently underway, such as a preliminary report in this proceedings (Animut et al., 2000), it appears that broiler litter has similar utility with goats.

2. Broiler Litter
2.1 Introduction

Poultry litter such as that from broiler production units or houses is abundant in many parts of the world, and in the US is often produced on relatively small farms. Therefore, disposal of the byproduct as fertilizer is frequently problematic. Broiler litter can be used as a ruminant feedstuff, with realized value under many conditions greater than with land application as fertilizer (Stephenson et al., 1990).

Broiler litter is composed of poultry excreta, bedding, feathers, spilled feed, etc. Contributions of these components vary considerably with poultry production practices, among and within regions of the world. In the US there has been a shift in broiler litter components in recent years. For example, in southwest Missouri and northwest Arkansas, some contract growers now use little or no absorbent bedding materials, but instead only remove packed or caked litter after each growing period. Conversely, in other areas of the US and(or) with different poultry companies, contract growers may totally clean houses and harvest litter after 1, 2, or 3 growing periods, with subsequent replacement of bedding materials and yield of litter relatively high in fiber.
Because of properties to be overviewed below, broiler litter is used most efficiently as a CP supplement. Properties of broiler litter possibly restricting use of dietary levels greater than required as a CP supplement include rapid and extensive microbial degradation of nitrogenous compounds to ammonia in the rumen and low to moderate digestible or available energy concentration. Nonetheless, because in part of relatively low cost, broiler litter is commonly used as a major dietary component.

2.2 Characteristics

2.2.1 Moisture

The moisture concentration in broiler litter ranges between 15 and 30% (Ruffin and McCaskey, 1990). The amount of moisture in litter is primarily influenced by water management systems in broiler houses, which have been improved in the last 10 years, resulting in litter considerably drier than previously. Type of bedding material may also influence moisture content, as water-holding capacity of common bedding materials varies. Although moisture in litter is not an important nutritional measure, a level greater than 25% suggests difficulty in handling (e.g., feed mixing), and litter with less than 12% moisture is often dusty and unpalatable (Ruffin and McCaskey, 1990). Furthermore, the moisture concentration in litter influences temperatures achieved in the most common method of processing, known as deep-stacking.

2.2.2 Crude Protein

Broiler litter is high in CP, typically ranging between 15 and 35% (dry matter basis). Nonprotein nitrogen usually accounts for slightly more than half of total CP, and amino acid nitrogen makes a somewhat lesser contribution. Uric acid represents roughly half of nonprotein nitrogen, with the remaining arising from compounds such as ammonia, urea, and creatinine. The level of ammonia in litter is much less than used in common ammoniation processes, being typically less than 1% of dry matter and making up approximately 10 to 25% of nonprotein nitrogen.

Most potentially digestible nitrogenous compounds in broiler litter are very soluble and rapidly degraded to ammonia in the rumen. The quantity of indigestible nitrogen in broiler litter is extremely variable, affected largely by the extent of heating in the deep-stacking process. The concentration of acid detergent fiber nitrogen has in some cases been over 50% of total nitrogen, although with proper deep-stacking levels are less than 20%. Likewise, as the concentration of acid detergent fiber nitrogen increases, indicative of heat damage, energy availability as well as that of nitrogen decline. Even though heating occurs in deep-stacks, there have been no reports of alterations of the nature of ruminal degradation of available nitrogenous compounds in broiler litter (Park et al., 1995a; Wang et al., 1996).

2.2.3 Fiber

Concentrations of neutral detergent fiber (NDF) in broiler litter are quite variable, affected by the number of growing periods before harvest and type of bedding material, as well as by extent of heat damage. Levels of NDF are usually between 30 and 60%. Acid detergent lignin concentration is also variable (e.g., 5 to 15%) and generally affected by the same factors influencing NDF concentration. Fiber in broiler litter, other than that from bedding materials, appears of relatively high ruminal digestibility (Park et al., 1995b).
2.2.4 Available Energy

Although availability of energy in broiler litter varies greatly, Ruffin and McCaskey (1990) reported an average TDN concentration in broiler litter used for feeding cattle in Alabama of 50%. As noted earlier, temperature during deep-stacking influences availability of energy. Another important factor is level of ash, with very high concentrations indicating excessive soil contamination and thus low dry matter and energy digestibilities. A wide range in ash concentration (10 to 54%; average 25%) of broiler litter was reported by Stephenson et al. (1990). Ruffin and McCaskey (1990) suggested that ash levels greater than 28% reflect insufficient energy availability for efficient feeding of ruminants.

2.2.5 Minerals

As suggested by relatively high levels of ash in broiler litter, the byproduct can be an excellent source of minerals such as calcium, phosphorus, potassium, magnesium, and sulfur, lessening need for other supplemental minerals. Excessive macromineral levels in broiler litter generally have not caused production problems. Although, Pugh et al. (1994) reported that lactating beef cows consuming broiler litter ad libitum suffered from a milk hypocalcemia, and Ruffin and McCaskey (1990) suggested removing brood cows from broiler litter diets at least 20 days before calving. Stephenson et al. (1990) presented an average copper concentration in broiler litter from 106 samples of 473 mg/kg. However, copper toxicities in cattle have not occurred as long as animals are not continually fed high levels of litter year-long.

2.2.6 Particle Size

Much of the fiber in broiler litter can be from bedding materials such as rice hulls and soft- and hardwood shavings, although appreciable and variable proportions also arise from other sources including undigested feed. Visually, bedding materials appear of largest size; hence, various particle size fractions could differ in chemical composition. For example, Phillips et al. (1993) noted that nitrogen concentration in broiler litter particles less than 1 mm in size averaged 6.3 percentage units and 29% greater than in particles greater than 3.2 mm. Crutchfield et al. (1996) observed considerable variation among broiler litter sources in mean particle size of dry matter, and that differences among litter sources in mean particle size of CP and NDF did not coincide well with those for dry matter. Marked differences in concentrations of chemical constituents occurred between very small (i.e., less than 0.55 mm) and larger particles; although concentrations of CP and NDF changed quadratically as particle size increased, perhaps because aggregates or clumps of small particles, as well as bedding materials, contributed to large particle size fractions.

Rossi et al. (1998) investigated possible feeding value differences among particle size fractions of broiler litter. Two sources of broiler litter were consumed by steers without separation or after separation (1-mm screen aperture) into small (27 and 33% CP and 35% NDF in the two sources) and large (22 and 18% CP and 39 and 51% NDF) particle size fractions. Source of broiler litter affected digestibilities more than did particle size fraction. Separating deep-stacked broiler litter into the two fractions did not alter feed intake or digestibilities compared with whole, unseparated litter. Nonetheless, if use of a small particle size fraction of broiler litter for a purpose in which a greater concentration of nitrogen and lower level of NDF are desirable and greater value realization from the byproduct results, the accompanying large particle size fraction could be used as a ruminant feedstuff without sacrifice of feeding value.
2.3 Broiler Production Units

Typically, broiler growing periods in the US are 6 weeks in length, with all birds in one-half of the house in the first 2 weeks (brood) and then distributed throughout the whole house in the final 4 weeks. Hence, differences in feeding value of litter from brood and non-brood areas might be expected. Goetsch et al. (1998) noted that litter harvested before the fourth 6-week broiler growing period yielded a lower organic matter concentration for brood than for non-brood litter. Organic matter concentration in non-brood litter stabilized after two growing periods, whereas that in brood litter increased linearly with increasing number of growing periods. There appeared greater potential to increase nitrogen concentration by delaying harvest of non-brood than brood litter; hence, for obtaining non-brood litter comparable to brood litter in nitrogen concentration, harvest after the fourth growing period was warranted. There was little or no effect of time of brood litter harvest on NDF concentration; however, for a NDF level in non-brood litter similar to that in brood litter, harvest after the third growing period was required.

2.4 Processing and Storage

Broiler litter used as a ruminant feedstuff in the US is typically processed through heating in a limited composting process, known as deep-stacking. Deep-stacked broiler litter is at least as high in feeding value as litter processing with greater oxygen exposure from composting (Patil et al., 1995b). For proper deep-stacking, the moisture content of broiler litter should be 20 to 25%, although levels slightly outside this range have been used with resultant litter of acceptable feeding value. With moisture levels less than 20% the rate of increase in temperature can be more rapid than with higher levels, although the time of peak temperatures may be shorter and the rate of subsequent decline in temperature more rapid. Deep-stacking improves palatability and eliminates potential hazards from pathogenic bacteria such as *Salmonella* and *Clostridium* (Fontenot and Webb, 1975; McCaskey and Anthony, 1979). For proper elimination of known pathogens, internal stack temperature should reach 55 to 60°C, and the stacking process should be for at least 20 days before feeding (Ruffin and McCaskey, 1990).

Excessive heat (> 60°C) reduces availability of nitrogen and energy through allowing the complete sequence of Maillard reactions, with irreversible binding of nitrogen and carbohydrate fractions. The most important factor influencing temperature is air exposure, with high oxygen availability permitting high activity of aerobic microorganisms in the stack, although other conditions such as physical constraints to heat dissipation are important as well. Air exposure can be easily limited to retard heating by covering the stack with plastic (Rankins et al., 1993; Wang et al., 1997). Stacking litter too high (> 1.8 m) promotes overheating and may necessitate covering.

Deep-stacks should be stored on a dry surface and preferably in a covered building. Stacks exposed to rain develop a thick, outside crust that can protect deeper litter from moisture, but high moisture and exposure to air in the outer layer can cause mold growth. Molds that produce mycotoxins are generally not a problem with litter protected from weather elements because of relatively high pH and ammonia presence.

2.5 Feedstuff Additions

2.5.1 Carbonaceous

A number of experiments have been conducted with additions of various substrates to broiler litter before deep-stacking to assess potential of enhancing feeding value of either broiler litter or added substrate. For example, Park et al. (1995b) and Wang et al. (1997) mixed urea with litter and low-quality forage substrates for ammonia concentrations comparable to those of conventional...
ammoniation processes. Fiber solubilization during deep-stacking typical of common ammoniation methods was observed with added bermudagrass and wheat straw, but without modification of ruminal digestibility of NDF present after stacking. Although, there appeared potential for a lower level of urea addition than used in conventional ammoniation processes. Park et al. (1997) added molasses at 5 and 10% of broiler litter dry matter, which appreciably decreased NDF and increased neutral detergent soluble organic matter concentration and in vitro NDF digestion, suggesting enhanced aerobic microbial degradation of fiber in the stack. However, digestible organic matter intake in steers was not affected by mixing of molasses with broiler litter before stacking (Wang and Goetsch, 1998). Adding other carbonaceous feeds (ground corn, whole corn, ground wheat, bermudagrass hay) to deep-stacks of litter has not appreciably changed nutritive value of stacked litter or mixtures relative to expectations based on simple additive effects (Park et al., 1997).

2.5.2 Ruminally Degraded Protein

Typical conditions (i.e., moisture concentration, pH, temperature) in broiler litter deep-stacks allow initial nonenzymatic browning or Maillard reactions, although conditions are not conducive to high reaction rates or the complete sequence. The long time during which broiler litter is deep-stacked (e.g., 3 weeks) compared with lengths much less than a day in common methods of inducing initial nonenzymatic browning reactions, such as with soybean meal (Cleale et al., 1987a, b, c; Demjanec et al., 1995; Hussein et al., 1995), appear to facilitate appreciable formation of early reaction products that are not degraded by ruminal microbes but are available for intestinal digestion. In support, Park et al. (1995a) mixed soybean meal with broiler litter before deep-stacking, with or without the reducing sugar xylose, and concluded that rumen undegraded protein concentration can be increased by adding a source of protein containing amino acids susceptible to nonenzymatic browning reactions to broiler litter before deep-stacking. Wang et al. (1996b) conducted a similar experiment with comparable findings; observed effects did, however, vary with length of deep-stacking but occurred without excessive loss of added nitrogen or with the necessity of simultaneous addition to the deep-stack of reducing sugars.

2.5.3 Condensed Tannins

Addition of a variety of condensed tannin sources to broiler litter before deep-stacking decreased assayable condensed tannin concentration, presumably via exposure to ammonia or moisture alkaline conditions (Patil et al., 1993; Wang et al., 1996a). Under conditions of these experiments, nutritional values of added substrates and broiler litter have not been depressed by deep-stacking, suggesting possible utility of such practices to upgrade feeding value of plant materials high in condensed tannins.

2.6 Broiler Litter Feeding
2.6.1 Residue Concerns

Medicinal drug residues have been found in broiler litter in variable amounts. However, residue concerns have not occurred with withdrawal of broiler litter from diets before marketing for slaughter (e.g., 15 days; Ruffin and McCaskey, 1990). Besides addition of copper sulfate to broiler diets causing high concentrations of copper in litter, arsenicals are often added to broiler diets as growth promotants. However, residues in tissues of cattle after broiler litter consumption have been similar or only slightly greater in concentration than in tissues of control cattle (El-Sabban et al., 1970; Webb and Fontenot, 1975; Westing et al., 1985). Also, arsenic in broiler litter is mostly in the organic form, which is less toxic than the inorganic, and levels of arsenic in broiler litter are below the maximum tolerable dietary levels of 50 ppm for inorganic and 100 ppm for organic forms (NRC, 1980).
2.6.2 Dietary Concentrate

Digestible energy concentration in broiler litter is lower than in concentrates and high-quality forages. Therefore, to achieve high performance of growing ruminants, concentrate feedstuffs, usually cereal grains, are mixed with broiler litter before feeding. Extensive ruminal fermentation of cereal grains increases the proportion of broiler litter nitrogen incorporated into microbial protein and minimizes ammonia absorbed from the rumen and subsequent urinary nitrogen excretion. During adaptation to broiler litter, dilution with cereal grain aids the familiarization process, although with proper deep-stacking palatability normally is not a problem.

Levels of cereal grains mixed and fed with broiler litter vary primarily with nutrient requirements, with lowest levels of grains given to mature cows in early to mid-gestation. Thus, it is expected that efficiency of nitrogen utilization would be lower for mature than for growing animals with greater ruminally fermentable organic matter. As fed litter to grain ratios offered free-choice range from 90:10 for cows to 50:50 for growing steers with potential for rapid growth. Some producers even have been successful in litter feeding without mixed grain, but with well adapted and accustomed animals. Even though different cereal grains vary in rate of ruminal digestion, there have been no reports of effects of grain type on efficiency of broiler litter usage (Patil et al., 1995a), probably because of the rapid and extensive conversion of broiler litter nitrogen to ammonia. Hence, palatability, ease of mixing, separation, and extent of ruminal digestion are major factors influencing suitability of available high-energy concentrate feedstuffs for feeding with broiler litter.

2.6.3 Dietary Forage

Stephenson et al. (1990) suggested that fiber in broiler litter can partially substitute for hay and other sources of dietary fiber. However, Ruffin and McCaskey (1990) reported that fiber in litter is inadequate to maintain motility of the reticulorumen because bedding materials usually are of finely ground, short particles. In fact, bloat can occur with all-litter diets (Barton, 1990). In some instances, digesta passage rate for basal dietary components with broiler litter consumption has been slow relative to diets without broiler litter (Patil et al., 1993, 1995a), and particulate passage rate for broiler litter has been lower than that of dietary forage (Patil et al., 1995a, 1995b). Such findings imply that physical characteristics of broiler litter could cause slow passage of digesta from the reticulorumen because of little stimulation of saliva flow and ruminal motility per unit of litter mass and, thus, limit feed intake (Patil et al., 1993). In this regard, Rossi et al. (1996) fed growing steers diets composed primarily of broiler litter with different quantities of long-stemmed grass hay (0.3, 0.6, and 0.9% of body weight) in order to vary ruminal motility and saliva production. Converse to previous findings, passage rate of broiler litter was not affected by level of hay intake, and passage rate of broiler litter from the reticulorumen was, in fact, greater than that of hay. Therefore, effects of physical characteristics of broiler litter on digestible nutrient intake and animal performance remain unclear.

Based on anecdotal evidence, it has been assumed that roughage or forage in high-broiler litter diets should compose at least 5 to 10% of total dry matter intake to avoid bloat. Although, higher levels may enhance energy absorption and animal performance; Rossi et al. (1996) observed greater digestible organic matter intake with long-stemmed grass hay consumed by growing steers at approximately 0.6% (approximately 15% of total dry matter intake) or 0.9% of body weight compared with 0.3%. Another common general guideline has been that light cattle (e.g., 180 to 205 kg) do not perform well while consuming diets high in broiler litter. However, this appears simply a function of available energy concentration rather than being specific to broiler litter, since digestible
organic matter intake by growing cattle at live weights of 135 and 180 kg consuming broiler litter-based diets was comparable to values with a moderate-quality grass hay diet (Rossi et al., 1996).

With diets very high in broiler litter consumed by animals with relatively low or moderate nutrient requirements, benefits of levels of forage above that required for normal rumen function and of grain greater than to achieve adequate acceptability of the litter-concentrate mix have not been extensively studied. Rossi et al. (1997) addressed this issue by feeding litter-based diets to gestating, spring-calving beef cows in a 63-day experiment in late-fall and early-winter. It appeared that with broiler litter at 60 to 70% of the diet, as long as a minimum level of dietary roughage is maintained for proper rumen function, different proportions of the remaining portion of the diet composed of roughage and cereal grain may have little or no impact on performance.

2.6.4 Dietary Broiler Litter Level

As noted previously, efficiency of use of broiler litter as a ruminant feedstuff is greatest when included at a low level only to provide needed ruminally degraded CP with low-protein forages such as cereal grain residues. Increasing level of broiler litter decreases efficiency of nitrogen usage, although animal performance may increase if available energy concentration is greater for litter than for the basal forage, as would be the case for forages such as wheat straw. Results of Rossi et al. (1996) highlighted above indicate that for growing/finishing ruminants with high nutrient requirements, achievable rates of growth with diets moderate to high in broiler litter are set by digestible energy intake. For such animals, more rapid growth can only be realized by use of greater levels of high-quality forage or concentrate feedstuffs. In this regard, low-quality forage chemically treated such as with ammonia could be used in broiler litter-containing diets, but only with elevated loss of ingested nitrogen in urine.

In various experiments in which moderate- to high-quality litter was consumed by growing cattle at up to approximately 70% of total intake in diets also with moderate-quality grass hay and cereal grain, dry matter and organic matter intakes were greater than for control diets based on moderate-quality grass hay. Because of lower organic matter digestibility of broiler litter than the grass hay sources used, the end-result was comparable digestible energy intake (Patil et al., 1993, 1995a, b; Rossi et al., 1996, 1998).

The maximal dietary level of broiler litter that can be used without impairing available energy intake and performance depends on litter quality. A high ash concentration indicates relatively low available energy concentration in dry matter. The number of growing periods before harvest also is important, as influencing the ratio of low-quality bedding to broiler excreta. Likewise, management practices such as application of bedding between growing periods affect the quantity of bedding in litter at harvest.

In accordance with effects of the number of broiler growing periods before harvest on litter chemical composition, energy intake can be impacted when in the diet at a moderate or high level. Wang and Goetsch (1998) noted that when at a high dietary proportion (e.g., > 40%), litter harvested after one broiler growing period elicited lower digestible organic matter intake by growing steers than litter obtained after at least three periods, whereas the number of broiler growing periods did not influence digestible energy intake with a lower dietary litter content (e.g., 20 to 40%) and moderate grain level.

Very high dietary inclusion levels of broiler litter have not been extensively studied compared with low and moderate proportions. But in a recent experiment (Rossi et al., 1997), broiler litter consumed free-choice in a mixture (as fed or as is basis) with 10% sorghum grain and with a
relatively low quantity of grass hay (e.g., 0.2% body weight) yielded lower body weight gain of beef cows than with either a higher quantity of grass hay (e.g., 0.6% body weight) or a higher percentage of sorghum grain in the mixture (e.g., 30%). However, the broiler litter used was harvested after only two broiler growing periods and, thus, was low to moderate in quality, with concentrations of ash, CP, and NDF of 30, 21, and 46%, respectively; similar results might not occur with higher quality litter. Also, even though body weight gain during the 9-week late-gestation feeding period was less for the high feeding level of broiler litter compared with lower levels, perhaps because of adequate digestible nutrient intake in the last 43 days of gestation and the first 62 days of lactation, no marked deleterious effects on calf birth weight or early lactation body weight gain or in subsequent cow body weight occurred.

2.6.5 Use With Grazing Ruminants

Although broiler litter has probably been most commonly used either as a nitrogen supplement of ruminants consuming low-CP forage or as a major dietary component when little or no growing herbage is available, because of its low cost relative to other available supplemental feedstuffs, uses in moderate amounts in grazing scenarios are being investigated. For example, Aiken et al. (1998) reported economical increases in live weight gain with feeding beef steers grazing endophyte-infected tall fescue a 50:50 (dry matter basis) broiler litter-ground corn mixture. Live weight gain was substantially greater for steers receiving the mixed supplement (0.67 kg/day) than for controls (0.37 kg/day). This improvement in performance was attributed to a lessening of intake of ergot-alkaloids in fescue rather than to an improvement in diet quality, such as assessed by in vitro digestion and concentrations of CP and NDF. Although, due to potential effects of ergot alkaloids on unsupplemented fescue intake (Goetsch et al., 1989), an increase in digestible energy intake might have contributed to the response as well. In another experiment, Aiken and Piper (1999) evaluated performance of steers grazing tall fescue at four stocking rates (3, 4, 5, and 6 animals per hectare) and fed daily a 50:50 mixture of broiler litter and ground corn at 1% of body weight. Live weight gain increased rather than decreased as stocking rate increased, which was attributed to both a lower concentration of ergot-alkaloids in the reduced mass of fescue available and consumption of the litter-corn mixture that prevented a decrease in total intake with increasing stocking rate.

3. Implications

Byproduct feedstuffs are very important in ruminant production systems throughout the world, and will continue to be so in the foreseeable future. Broiler litter, a byproduct of poultry production, is high in crude protein rapidly degraded in the rumen and variable but generally low to moderate in available energy concentration. Hence, broiler litter is most efficiently used as a crude protein supplement, but because of relatively low cost litter is frequently used at dietary levels greater than to simply provide additional crude protein. Future research is needed to adequately characterize composition of high-broiler litter diets to enhance efficiency of utilization, investigate potential uses of the unique conditions existing during the lengthy heat treatment processing method, and evaluate efficacy of broiler litter when employed as a low-cost byproduct feedstuff for goats. Besides an associated lessening of feedstuff expenses, broiler litter inclusion in ruminant diets can elevate production with set resources and improve sustainability of livestock and poultry production through bioresource recycling.
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