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DEHYDRATED ALFALFA AS A PROTEIN SOURCE IN RUMINANT RATIONS

by

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TITLE

Dehydrated Alfalfa as a Protein Source in Ruminant Rations

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DEHYDRATED ALFALFA AS A PROTEIN SOURCE IN RUMINANT RATIONS

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University of Nebraska, 1973

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Dehydrated alfalfa was evaluated as a protein source in two lamb finishing trials, one steer growing trial, one steer finishing trial and in two lamb metabolism trials. Two in vitro ammonia release trials were conducted to determine the effect of heat drying on alfalfa and to compare the relative ammonia release of dried alfalfa to soybean meal. Four abomasal sampling trials were conducted to determine the proportion of dehy that bypassed the rumen.

In the two in vitro ammonia release trials, alfalfa, oven-dried at temperatures greater than 60^{o} C., produced significantly less ammonia in four hours than soybean meal. Fresh alfalfa, freeze-dried or oven-dried at temperatures of 60^{o} C. or less produced slightly, though not significantly, less ammonia in four hours than soybean meal.

In two lamb trials, dehy additions to finishing rations resulted in increased lamb gains. Dehy additions to urea supplemented rations resulted in greater increases in lamb gains than dehy additions to soybean meal supplemented rations. Feed efficiencies followed the same trend.

A steer growth trial was conducted to evaluate the effects of dehy-urea combinations in 50% corn cob growing

rations. Steers fed the dehy-urea combination rations gained at the same rate as steers fed the soybean meal supplemented ration and at significantly greater rates than steers fed the urea supplemented ration. Steers fed the dehy-urea combination rations were slightly less efficient in converting feed to gain than steers fed the soybean meal supplemented ration, but they were significantly more efficient in converting feed to gain than steers fed the urea supplemented ration.

In a steer finishing trial, dehy additions significantly depressed gains. The dehy may have been overheated during the dehydrating process.

A lamb metabolism trial was conducted to evaluate the effects of 0, 10, or 20% dehy additions to 20% corn cob rations supplemented with either soybean meal or urea. Significant linear increases in lamb nitrogen retention was observed as dehy was added to the ration. Lambs fed the soybean meal supplemented rations retained slightly, though not significantly, more nitrogen than lambs fed the urea supplemented rations.

A second lamb metabolism trial was conducted to evaluate the effects of dehy or dehy-urea combinations in rations containing 50% wheat straw. Lambs fed a urea supplemented ration retained significantly less nitrogen than lambs fed lambs fed rations supplemented with either soybean meal, dehy-urea or dehy. Lambs fed the dehy supplemented ration retained as much nitrogen as lambs fed the soybean meal

supplemented ration. Lambs fed the dehy-urea supplemented ration retained slightly, though not significantly, more nitrogen than lambs fed the soybean meal or dehy supplemented rations.

Abomasal sampling trials were conducted to determine the quantity of dehy and soybean meal protein that bypassed rumen degradation. Rumen bypass of dehy nitrogen was 68%, while soybean meal nitrogen bypass was 43.6%. Large within trial variation was observed in the values constituting the averages for dehy and soybean meal bypass. The quantity of dehy bypassed, per unit of feed consumed, was constant.

INTRODUCTION

Alfalfa is widely accepted as an important feedstuff for livestock. When fed to ruminants, alfalfa is regarded as a near perfect feed. With the exception of salt, good quality alfalfa supplies enough energy, vitamins, minerals and protein to meet the requirements of many classes of ruminants. Thus, alfalfa is widely used in rations fed to all ages and types of cattle.

Dehydration of alfalfa is beneficial in preserving its best qualities. As a result mechanical dehydration has become a major enterprise in many states where alfalfa is grown. Alfalfa is dehydrated by forcing flame-heated air through revolving drums containing chopped, fresh alfalfa. The length of time the fresh alfalfa is retained in the drum, and the temperature of the air forced into the drum, influences the quality of the dehydrated product.

If alfalfa is harvested at immature stages or leaves are separated from stems, protein content may be as high as 30% of the dry matter, and amount to as much as two times the protein production per acre as soybean meal. Thus, alfalfa is an important source of supplemental protein in both ruminant and nonruminant rations.

The rumen is a major site of feedstuff digestion due to the microbial population which exists in a symbiotic relationship with the host. Rumen microbes are capable of digesting many feedstuffs not digested by the host itself.

The microbial population, then, upgrades low quality feedstuffs to products the host animal can utilize. The microbes digest feedstuffs for their own use, but due to their location in the ruminant's gastrointestinal tract, the by-products of microbial digestion, and the microbial population itself become a major source of nutrients for the host.

Unfortunately, high quality feedstuffs such as dehydrated alfalfa (dehy), readily digested by the host, are also largely digested by rumen microbes. This occurs because the rumen is the first compartment of the stomach into which food enters. The abomasum, small intestine and large intestine are located beyond the rumen and function similarly to the digestive system in monogastrics.

High quality feedstuffs, especially high quality protein, could be more efficiently utilized if microbial digestion did not occur. To prevent microbial digestion, the rumen must be bypassed. This could be accomplished by either closing the esophageal groove, or by allowing the food to enter the rumen, but slowing or halting microbial digestion.

Some workers were successful in improving calf and lamb gains by closing the esophageal groove. This method is not a practical method of promoting rumen bypass.

Prevention of rumen degradation would appear to be more applicable to normal feeding operations. Ruminants fed high quality proteins, treated with aldehydes or tannins, have

had reduced rumen protein degradation and improved body weight gains.

Heating may be another method of reducing protein degradation in the rumen. Since alfalfa is heated during dehydration, the temperature could be controlled to permit maximum bypass.

Heating may also be detrimental. Overheating a protein has been detrimental to both protein digestibility and protein utilization in monogastrics. The effects of overheating protein for ruminants, while expected to be similar to monogastrics, has not been clearly demonstrated.

This study was initiated to determine the effect of dehydrated alfalfa fed as a protein source in cattle and lamb finishing rations and in cattle growing rations. Dehydrated alfalfa was compared to soybean meal and urea. _In vitro_ studies were conducted to determine the effect of drying temperature on the availability of alfalfa protein for microbial degradation. Lamb nitrogen balance and nitrogen digestibility studies were conducted to determine nitrogen availability and utilization of dehydrated alfalfa protein. Abomasal samples were collected from lambs to determine the quantity of alfalfa protein which escaped rumen degradation.

LITERATURE REVIEW

Review of Alfalfa Literature

Dehydrated alfalfa has many assets, some of which are not fully recognized by ration formulators (Hunter, 1969). Alfalfa is used as a protein-zanthrophyll, and/or vitamin source in monogastrics, and as a protein, vitamin or roughage source in ruminants. Dehy has also been formulated into ruminant rations because of its complimentary effects with urea (Velloso and co-workers, 1971; Horn and Beeson, 1969; Van Slyke, et al., 1971). These effects may be due to unidentified urea-protein factors found in the dehy (Garrigus, 1964; Beeson and Horn, 1967; Briggs, et al., 1972).

When dehydrated alfalfa is considered as a protein source in livestock rations, the effect of processing on the protein must be considered. Meduna (1970) reported lamb studies where protein of dried alfalfa leaves was 10.8 percentage units less digestible than protein from soybean meal. The five hour postfeeding rumen ammonia concentration of lambs fed a ration of dried alfalfa leaves was 17.34 mg./100 ml. of rumen fluid, while the rumen ammonia concentration of lambs fed a concentrate ration containing an equal amount of protein from soybean meal was 48.11 mg./100 ml. of rumen fluid. The total digestible nutrients of both rations were equal. Booth and co-workers (1972) reported that protein digestibility of dried alfalfa,

decreased as the dryer temperature increased from 250 to 290° F. These workers also found that during the procedure of obtaining an alfalfa protein concentrate, the steam-coagulation step caused a decrease in *in vitro* protein digestibility of the alfalfa protein concentrate. Drying the coagulated protein at 250 to 290° F. caused a further decrease in *in vitro* protein digestibility. Klopfenstein (1968) reported that *in vivo* protein digestibility was drastically reduced when 400 psi of steam pressure was used on alfalfa stems in an attempt to increase stem dry matter digestibility.

Livingston and co-workers (1971) reported that drying 94% dry matter alfalfa in a laboratory dehydrator to low (1.5%) moisture content, caused approximately 23, 6, 11, and 14 percentage units loss in the amino acids lysine, cystine, methionine, and aspartic acid, respectively. Drying alfalfa to 6% moisture from 10% moisture caused a 12, 10, 6, and 4 percentage units loss in lysine, cystine, arginine, and methionine, respectively. Lysine destruction may occur more rapidly in the leaves than in the stems of alfalfa, due to the thickness of the particles. Leaves may dry faster, therefore they are subjected to higher drying temperatures than the thicker stem particle. Amino acid destruction would then be greater in the leaf particle. Livingston and co-workers (1971) have shown that alfalfa leaves contain .75 gm. less lysine per 16 gm. of nitrogen than stems.

Data on the value of alfalfa protein in ruminant rations are limited. The preceding paragraphs have cited much of the data collected concerning dehy protein and changes occurring during dehydration. The depression in digestibility of alfalfa protein, which was heated during dehydration, may not be completely detrimental. Reduced rumen degradation of alfalfa protein, as shown by low rumen ammonia levels (Meduna, 1970), may be beneficial if alfalfa protein can bypass the rumen and be substantially degraded in the abomasum and small intestine.

The remainder of the literature review will attempt to document the theory that heating during dehydration can have beneficial effects on ruminant performance. The anatomical characteristics along with the effects of the rumen microbes on the digesta reaching the lower digestive tract are important. For this reason, protein digestion in each particular area of the ruminant gastrointestinal tract must be considered. Due to the limited data available on alfalfa protein, other proteins are reviewed with the assumption that much of these data are relevant to protein in general.

Protein Degradation and Formation by Rumen Microbes

Proteins, easily digested by monogastrics, are mostly degraded by the microbial population in the rumen to V.F.A.'s and NH_3. McDonald and co-workers (1957) and Chalmers et al. (1954a) have shown that 90% of the casein ingested was degraded in the rumen. Other workers added L-arginine, L-

lysine, or D-L-tryptophan to cattle rations and caused increased NH_3 levels in the rumen (Lewis and Emery, 1962).

The products of protein degradation, especially NH_3, are not all resynthesized into protein by rumen microbes, due to the absorption of portions of these products from the rumen. The NH_3 from the rumen enters the host's blood stream (Chalmers et al., 1954a), and travels to the liver where it is converted to urea for subsequent excretion in the urine (McDonald, 1948). Therefore, nitrogen sources producing high rumen NH_3 levels may not be as efficiently utilized as sources producing low rumen NH_3 levels. Pilgrim et al. (1970) have shown that rumen microbes more efficiently utilize N^{15} infused into lamb rumens, when lambs are fed a low nitrogen diet than when lambs are fed a high nitrogen diet. Lambs fed the low nitrogen diet were 15 to 16% units more efficient in converting dietary nitrogen to microbial nitrogen than lambs fed the high nitrogen diet. These workers concluded that microbial protein synthesis was more dependent on NH_3 concentration in lambs fed the low nitrogen diet than in lambs fed the high nitrogen diet. Hume and co-workers (1970) fed lambs a protein free purified diet to which 2, 4, 9, or 16 grams of nitrogen per lamb per day were added. The most efficient utilization of the nitrogen ingested was with lambs fed the low nitrogen diet, but optimum microbial protein production occurred when nitrogen was in excess of the microbe's requirements. When nitrogen was most limiting, the protein yield in the rumen was 9.1 grams

per 100 grams of digestible organic matter, while 13.3 grams per 100 grams of digestible organic matter was formed when dietary nitrogen was in excess.

The efficiency of nitrogen utilization may be dependent upon more factors than nitrogen availability. Walker and Nader (1970) fed sheep lucerne and wheat hays estimating the rate of ruminal protein synthesis and V.F.A. production at four hour intervals after a single feed. They found protein to be synthesized at the slowest rate four hours after feeding, while the highest rate of protein synthesis was found to be at 12 hours postfeeding. When protein synthesis was placed in relation to energy supply, the lowest production was at four hours, but the peak of protein synthesis never occurred until 20 hours postfeeding. In addition, increasing polysaccharide levels in the bacterial cells were correlated to decreasing energy utilization for protein synthesis. As the cellular polysaccharide level returned to prefeeding values,there was an increase in energy use for protein synthesis. It was estimated that 12.3 grams of crude protein was generated per mole of V.F.A. produced. This value could be converted to 14.4 grams of microbial crude protein per 100 grams of digestible organic matter.

Bauchop and Elsden (1960) studied the dry organism growth of pure cultures of Streptococcus faecalis, Pseudomonas lindneri, and Saccharomyces cerevisiae per mole of adenosine triphosphate synthesized. An average of 10.5 grams of dry organism per mole of ATP was reported. Various

energy sources were compared. One mole of fermented glucose produced 4 moles of ATP, while 1 mole of either fermented glycerol or lactate produced 2 moles of ATP.

Annison et al. (1954) reported that rumen NH_3 production from a given amount of protein rich material decreased when the quantity of starch or cereal meal fed at the same time was increased. This indicates that energy availability in the rumen affects rumen ammonia concentrations.

Ummuna (1972) reported in vitro work indicating that branched-chain V.F.A.'s would increase protein synthesis, compared to treatments with no branched-chain V.F.A.'s. These V.F.A.'s may have been used by the rumen microbes as carbon skeletons for protein synthesis.

Effect of Protein Source on Rumen Protein Degradation

The type of protein degraded in the rumen may have an effect on the quantity of microbial protein produced. Hume (1970) reported the effect of different dietary proteins on microbial protein synthesis. Lambs were fed a protein free diet containing 600 grams of digestible organic matter per day. Urea was added as a control nitrogen source and higher V.F.A.'s were added as an energy source. Daily microbial protein synthesis in lambs fed the diet with urea and V.F.A.'s was 90 grams. When gelatin, casein, or zein replaced the higher V.F.A.'s and 50% of the urea-nitrogen, microbial protein production was 91, 101, and 104 grams per day, respectively. At least 7.5 grams of nitrogen per day were recycled into the rumen by lambs fed the zein diets, but