FEATHER MEAL IN WINTER SUPPLEMENTS FOR BEEF COWS

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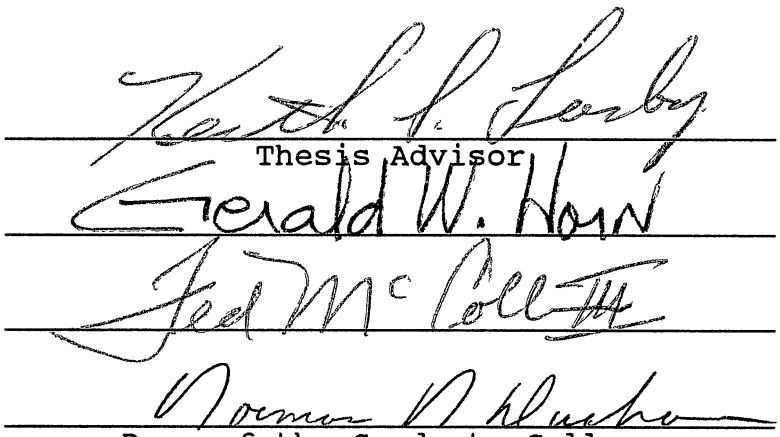

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CHAPTER I

INTRODUCTION

Large numbers of cattle in Oklahoma are maintained on dormant forages throughout the winter. The crude protein (CP) content of these forages is low at the beginning of dormancy and decreases further when fall and early winter rains leach out nutrients (Waller et al., 1962). Because the CP requirements for lactating and non-lactating cows in mid to late gestation are greater than provided by forages, protein supplements are provided to increase nutritional status. These protein supplements have traditionally consisted of natural plant proteins such as soybean meal (SBM) and cottonseed meal. Because these protein sources are expensive, a less expensive means of providing the required supplemental protein would decrease the costs of supplementation and decrease the costs of cattle production.

Byproduct feeds of the slaughtering industry have received much attention for use in supplemental feeding programs. Some of these byproducts are meat and bone meal, blood meal and feather meal. These byproducts are high in CP and are often less expensive per unit of CP than plant proteins. Most of the CP in these meals escapes degradation within the rumen and is absorbed in the lower digestive

tract. Thus they potentially offer a more efficient means of meeting protein requirements by decreasing the amount of protein that is degraded by rumen microbes.

Many studies have evaluated FM in growing and finishing cattle diets. Wray et al. (1979) found no difference in daily gains of steers receiving FM compared to those receiving SBM-based rations. Rakes et al. (1968) reported that lactating dairy cattle performed satisfactorily when FM replaced all plant proteins in their diets.

Few studies have tested FM in protein supplements for beef cows wintered on dormant warm season forages. If FM could replace SBM in protein supplements for cows, a significant savings in protein costs would be realized. The CP content of FM is approximately twice that of SBM, and only half as much FM would have to be purchased to obtain the same supplemental protein level. With close proximity to major poultry processors throughout eastern Oklahoma and Arkansas, FM is readily available in Oklahoma and usually at a reasonable price compared to the cost of protein from oilseed meals.

The purpose of this study was to evaluate the performance of spring- and fall-calving beef cows grazing dormant native range and receiving protein supplements containing hydrolyzed feather meal. In addition, an in situ nitrogen (N) degradation and pepsin N digestibility trial was conducted to determine the amount of FM nitrogen that is

degraded within the rumen, and also the amount N that is potentially digestible within the lower digestive tract.

CHAPTER II

REVIEW OF LITERATURE

Forage Quality

Quality of range forages declines dramatically during the later stages of the growing season. The amount of crude protein (CP) contained in native tall grass prairie declines steadily from May to mid-August while the amounts of indigestible residues increases (Campbell and McCollum, 1989). These changes are due to an increase in the stem to leaf ratio which is associated with an increase in overall ADF content of the forage. Autumn rains can further decrease the nutritional value of these forages by leaching of nutrients. Because most beef cows in Oklahoma are maintained on these low quality dormant forages throughout the winter months, a means of enhancing animal performance by increasing utilization of forages is needed.

Providing energy concentrates to grazing animals is a potential means of improving the energy status of the animal. However, negative associative affects between concentrates and roughages often decrease forage utilization (Rittenhouse et al. 1970; Chase and Hibberd, 1985; Sanson and Clanton, 1989; Horn and McCollum, 1987). A decrease in ruminal pH (below 6.2) may occur when starch is rapidly

fermented in the rumen and can inhibit the function of cellulytic microbes and thus reduce fiber digestion (Orskov, 1982).

Protein Supplementation

If the supply of forage is not limiting, small amounts of high protein supplements will enhance fiber digestion and forage intake (Rittenhouse et al., 1970; Guthrie and Wagner, 1988; McCollum and Horn, 1990; Solaiman et al., 1990). Petersen (1987) reviewed three modes of action which improved animal performance when supplemental protein is fed. First, supplements can supply the minimum requirements for nitrogen (N), amino acids and/or carbon chains for bacterial protein synthesis. Second, supplementation may improve rumen dynamics and the flow of both N and non-N containing compounds to the lower tract. Third, supplements may satisfy protein quantity or quality requirements increasing microbial and/or feed protein presented to the small intestine.

Rumen microbes can utilize N in the form of ammonia (NH_3) or amino acids for the synthesis of protein. Providing protein supplements to cattle consuming low quality roughages can increase the concentration of NH_3-N within the rumen. In a study by McCollum and Galyean (1985), ruminal NH_3-N in steers consuming prairie hay (6.1% CP) varied from 1.8 to 3.4 mg/dl depending on time of sampling. Providing steers with 800 g/d of cottonseed meal

(CSM) increased the range of ruminal NH_3-N concentration levels from 5.4 to 10.5 mg/dl as compared to unsupplemented controls. Stokes et al. (1988) reported that unsupplemented beef cows maintained on dormant forages had ruminal ammonia concentrations $\leq$ 1 mg/dl while the provision of SBM at .24% body weight (BW) significantly increased concentrations.

McCollum and Horn (1990) in a review of protein supplementation, reported many estimates for the optimal ruminal NH_3-N concentration. Values ranged from 1 to 22.1 mg/dl depending on criteria and substrates used in the evaluations. However, concentrations above 5 mg/ml have been reported not to improve bacterial protein production (NRC, 1984). Stanton et al. (1983) in a study with lactating beef cows grazing dormant native range, reported that cows with ruminal NH_3-N concentrations of 2.7 to 4.5 mg/dl performed similarly to those with concentrations of 15.5 to 20.6 mg/dl.

If ruminal ammonia levels were the only factor limiting animal performance on low quality forages, then supplementation of non-protein nitrogen (NPN) sources such as urea should be beneficial. Many studies have shown little or no response when grazing ruminants received supplemental NPN as compared to natural proteins (Nelson and Waller, 1962; Rush and Totusek, 1976; Kropp et al., 1977). Kropp et al. (1977) maintained steers on low quality roughages and fed protein supplements in which urea replaced 0, 25, 50 or 75% of the supplemental SBM nitrogen.

Digestibility of dry matter (DM), organic matter (OM) and N, and N retention decreased as urea replaced more SBM in the ration. The decreasing response to supplemental NPN could be attributed to the fact that forage N may have only been partially limiting. Orskov (1982) reported that many low-quality roughages are only marginally deficient in N because of their potentially low fermentability and therefore low digestibility. In a study cited by Orskov (1982), sheep were provided free access to treated (NaOH) and untreated barley straw. Upon application of urea to the straw, no significant increase in intake or digestibility was seen with the untreated straw, while intake increased 60% and digestibility increased 40% with the NaOH treated straw. This illustrates that NPN does not increase the potential digestibility of low quality forages, but only assists in realizing the potential digestibility (Orskov, 1982).

Although rumen microbes are able to synthesize amino acids from substrates in the rumen, supplemental amino acids or branched-chain fatty acids in purified diets will increase both microbial yield and rate of growth (Maeng and Baldwin, 1976; Orskov 1982). Using in vitro studies using short-term incubations of whole rumen contents, Maeng and Baldwin (1976) found that small additions of amino acids increased microbial cell yield by 36 to 62% as compared to urea. Hespell and Bryant (1979) reported that a decrease in microbial yield and growth rate results when amino acids are limited because of increased energetic uncoupling.

Energetic uncoupling refers to the relative degree to which ATP or other energy rich compounds, that are produced from catabolic activities, are utilized by anabolic activities of the cell (Senez, 1962). The decrease in microbial yields may not be strictly due to the restriction of amino acids. Shortages of carbon skeletons and/or oligopeptides produced by deamination of amino acids may restrict the growth of certain ruminal bacteria (Hespell and Bryant, 1979). Also, some VFA's produced from deamination of amino acids, which are essential or stimulatory for some species of bacteria, may have their greatest effect in media devoid of N sources other than NH_3 or urea. "Thus it can be speculated that lack of sufficient concentrations of amino acids, of VFA's derived from amino acids, or of oligopeptides may increase energetic uncoupling resulting in lower microbial cell yields relative to ATP formed via fermentation acid production in the rumen or to the amount of cellulose catabolized (degraded or digested) in the rumen" (Hespell and Bryant, 1979).

Rumen Dynamics

Although the protein content of grazed forages may be low, perhaps the true deficiency is not one of N but rather one of energy. Limitated forage digestibility coupled with the limited ruminal capacity may not permit the animal to obtain enough energy to maintain performance on low-quality roughages. Increased DM intake and digestive kinetics have

been reported with protein supplementation of ruminants receiving low-quality forages (Weston, 1967; McCollum and Galyean, 1985; Krysl et al., 1987; Stokes et al., 1988; Guthrie and Wagner, 1988). In the study by Guthrie and Wagner (1988), heifers receiving prairie hay (4% CP) and increasing amounts of SBM (121, 241, 362 and 603 g/d),had greater DM intakes (5.15, 5.63, 6.61, 6.95 and 7.85 kg, respectively) and particulate passage rates (2.08, 2.17, 2.63, 2.86 and 3.47 %/h, respectively) than unsupplemented controls. McCollum and Galyean (1985) reported similar results when prairie hay was fed to steers receiving CSM supplements. Particulate passage rates were increased (4.5 vs. 2.9 %/h) for supplemented steers compared to controls, and DM intakes increased from 16.9 to 21.5 g/kg BW. In contrast, Krysl et al. (1987) reported no increase in particulate passage rate of ewes receiving CSM at a rate of 80 g/d, although fluid dilution rates were improved with supplementation. Whether increased passage rates are the result of greater intakes, or if greater intakes are the result of increased passage rates, is still a matter of debate (McCollum and Horn, 1990). Regardless of the interpretation, animals are able to consume more forage and thus, the overall energy status of the animal may be improved.

Bypass Proteins

Bypass proteins offer a means of providing additional nutrients (protein and/or amino acids) to the lower digestive tract without first being degraded by the rumen microbes. Many bypass proteins are byproducts from animal processing industries. These include meat and bone meal, blood meal, fish meal, feather meal and/or many combinations of these. Chemically- and heat-treated oilseed meals have also been investigated as sources of bypass proteins (Stanton et al., 1983).

Many authors agree that a response to bypass proteins will not be seen until the ruminal NH_3 requirements are met (Stanton et al., 1983; Owens, 1986; Petersen, 1987; McCollum and Horn, 1990). Also, beneficial responses to bypass proteins may not be seen if 1) the bypass protein is poorly digested in the small intestine, 2) the balance of amino acids in intestinal ingesta is poor, or 3) energy supply or nutrients other than amino acids are limiting animal performance (NRC, 1984).

Bypass proteins do offer a means of augmenting animal performance in certain situations. Gonzalez et al. (1985) reported that a 9% reduction in DM intake accompanied with a reduction in the digestibility of organic matter occurred with ewes in late pregnancy as compared to non-pregnant ewes. The quantity of non-ammonia nitrogen available for absorption in the small intestine was significantly greater in late pregnancy as compared to postweaning, this was

explained by a reduction in the degradation of dietary protein associated with a shorter retention time. Supplementing bypass proteins could offer a means of supplying a larger amount of high-quality nutrients to the lower tract without increasing feed intake.

The large amounts of energy and other nutrients required for milk production also offer an ideal situation for the inclusion of bypass proteins into supplements. The onset of milk production following parturition is not simultaneously accompanied by an increase in intake, thus a lag time is evident between peak milk production and peak intake (Clark and Davis, 1980). In a study by Hibberd et al. (1988), lactating beef cows on dormant range were given protein supplements (.64 kg/d) which contained either .18 or .32 kg of bypass protein from BM. Cows receiving the higher level of bypass protein lost less weight (11.8 vs. 17.2 kg) and produced more milk (.77 vs. .45 kg/d) than did cows consuming the low level of bypass protein. However, in a subsequent study, no response was noted when the same supplements were provided (Hibberd, personal communication).

The use of some bypass proteins in winter protein supplements may be limited by their relative scarcity or high cost. However, with the close proximity to the major poultry processors in eastern Oklahoma and Arkansas, FM is readily obtainable and at a reasonable price compared to protein from oilseed meals.

Feather Meal

Definition

Hydrolyzed feather meal is a byproduct of the poultry processing industry. It is defined by the American Association of Feed Control Officials (AAFCO) as "the product resulting from the treatment under pressure of clean undecomposed feathers from slaughtered poultry free of additives and/or accelerators. Not less than 75% of its CP shall consist of digestible protein by the pepsin digestibility method" (AAFCO, 1987).

Feathers contain keratin protein that is high in the amino acid cysteine. Disulfide bonds between cysteine molecules make it relatively undigestible in the natural state (Sullivan and Stephenson, 1957; Davis et al., 1961; Moran et al., 1967). Processing (hydrolyzation or chemical) is necessary to break the disulfide bonds to allow the protein to be utilized.

The CP content of FM ranges from 80 to 90% on a DM basis. However, the quality of FM obtained from different commercial sources is highly variable (Retrum, 1988). Variations result from the processing techniques as well as the amounts of blood and offal contained within the meal (Retrum, 1988).

Although disallowed by the AAFCO definition, feather meal obtained from commercial sources contains variable amounts of blood and offal. If all of the blood from

slaughtered poultry were included in the meal about 10% of the DM of the meal would be blood (Retrum, 1988; Goedeken et al. 1990b). Goedeken et al. (1990b) reported that a 15% reduction in digestible escape protein occurred when blood was hydrolyzed with feathers compared to addition of blood following hydrolysis.

In a mechanized kill facility a large amount of heads and feet offal can be deposited in the feathers (Davis et al., 1961). The offal content of FM ranges from 10 to 30% on a DM basis (Retrum, 1988). Higher offal contents lower the quality of FM by increasing the fat and ash, and decreasing the protein content of the meal (Retrum, 1988).

Processing

Many different methods of processing have been used to produce FM. Hydrolyzation, which is used to produce most of the commercial FM, involves the steam-cooking (140 to 150^{o} C) of feathers under pressure (2.8 to 3.5 kg/cm^{2}) in a closed cooker, usually with constant agitation (Davis et al., 1961; Thomas and Beeson, 1977; Aderbigbe and Church, 1983a). Cooking time ranges from 30 to 45 min after the optimum heat and pressure have been reached (Davis, 1961; Thomas and Beeson, 1977). The resulting slurry is cooked an additional hour to drive off excess moisture. The material is then transferred to a steam tube or hot air drier and dried to 6 to 8% moisture (Retrum, 1988). Scorching or

over-drying the meal will decrease protein digestibility (Retrum, 1988).

Jordan and Croom (1957) added hydrated lime to feathers to produce a friable meal without internal steam pressure. Such a technique would lower the cost of production by reducing the amount of energy required. Other studies have utilized chemical treatments of alkali (Harrap and Woods, 1964; Steiner et al., 1983) or acid (Earland et al., 1955; Steiner et al., 1983) in an attempt to reduce steam processing time. Once ground, the product is a free flowing meal with excellent pelleting quality.

Digestibility

In Vivo. A high percentage of the protein in hydrolyzed FM escapes degradation in the rumen (Wray et al., 1980; Church et al., 1982; Goedeken et al., 1990a). In a review of bypass proteins, Owens (1986) reported the escape value of the protein in FM to average 69%. Higher ruminal NH_3-N concentrations were observed for ruminants fed SBM compared to FM (Waltz et al., 1989; Thomas and Beeson, 1977) which would suggest that more of the CP contained within SBM was degraded in the rumen. Waltz et al. (1989) fed lactating dairy cows rations containing either FM or SBM. Ruminal concentration of propionate was higher for cows consuming SBM. According to Veen (1986), increased amounts of propionate are produced when proteins are fermented by bacteria.

In studies by Thomas and Beeson (1977) and Wray et al. (1980), steers consuming FM showed greater fecal nitrogen excretions than did those consuming SBM, indicating a higher apparent N digestibility for SBM. Waltz et al. (1989) also noted higher fecal N excretions in dairy cows consuming FM supplements. However, N retention was not affected by protein source as steers consuming SBM excreted more urinary N. They concluded that this affect was the result of a higher retention of absorbed N by the FM-fed steers. The apparent total tract digestibility of FM by ruminants has been reported to range from 59 to 73% (Thomas and Beeson 1977; Wray et al., 1980; Waltz et al., 1989).

Goedeken et al. (1990b) reported no differences in apparent N digestion between lambs consuming FM or SBM. However, in this study urea was included in the diet to prevent a shortage of ruminal N.

In Vitro. Pepsin digestibilities (PD) of FM range from 63 to 85% (Church et al., 1982; Steiner et al., 1983). Davis et al. (1961) reported that pepsin-HCl digestibility of FM increased with increasing time or pressure of steam cooking. Aderibigbe and Church (1983c) processed FM with varying exposure times but at constant pressure (1.05 kg/cm^2) to determine if a change in PD would occur. Their results agreed with the previous study (Davis et al., 1961), in that pepsin digestibility increased with increasing processing time (7% at time 0 to 63% at 90 min). No effect

of processing on the N content of FM has been reported (Aderibigbe and Church, 1983c; Steiner et al., 1983).

Pepsin digestibility is not a good estimate of the biological availability or nutritive value of FM (Retrum, 1988). High pepsin digestibility, as previously stated, is a reflection of increased degree of processing. Owens (1986) reported that with excessive heat treatment, indigestible complexes between amino acids, especially lysine and sulfur amino acids, can be formed. Feather meals with extremely high pepsin digestibility may be undesirable because over-processing can destroy individual amino acids resulting in a lower quality meal (Davis et al., 1961). Pepsin digestibility values below 65% may reflect an under-processed meal, or one that has a high blood and/or offal content (Retrum, 1988).

Amino Acid Profile

The utilization of FM as a source of dietary protein for nonruminants is limited by its amino acid imbalance. Although FM is high in the sulfur amino acid cysteine, limited amounts of the essential amino acids methionine and lysine have been found in the rat and chick (Routh, 1942; Moran et al., 1966). It has been reported however, that cysteine can be used to replace more than 50% of the methionine required by young chicks (Graber et al., 1971; Sasse and Baker, 1974).

Contradictary results have been found when chick diets containing FM were supplemented with essential amino acids. Naber et al. (1961) found the performance of chicks fed FM supplemented with amino acids to be lower than that of chicks receiving a corn-SBM diet. Moran et al. (1966) reported an increase in chick performance with FM diets supplemented with amino acids as compared to an isolated SBM diet.

Methionine and lysine are the first limiting amino acids for microbial protein synthesis (Nimrick et al., 1970; Fenderson and Bergen, 1975; Richardson and Hatfield, 1978). Although the lysine content of FM is low, Hill and Ellis (1991) reported that lysine is almost completely degraded within the rumen. To supply needed lysine, the addition of BM to FM supplements has been studied (Goedeken et al., 1990b). An improvement in steer performance was reported with the addition of BM to FM as compared to FM or SBM rations alone. The increase in performance was attributed to an increase in the amount of ruminally degradable lysine.

The addition of FM to rations is further complicated by the fact that methionine, is first limiting for the rumen microbes, in FM almost completely escapes degradation within the rumen (Hill and Ellis, 1991). Optimal microbial growth cannot be achieved without a supply of sulfur (Orskov, 1982). The sulfur requirement of microbes is related to the requirement of N, because the sulfur-containing amino acids comprise a constant proportion of microbial amino acids.

The proper ratio of N:S within the rumen varies, but an average of 14:1 has been reported (Orskov, 1982). Thus with the inclusion of FM to rations, the rumen environment may lack N and sulfur-containing amino acids.

As previously reported, cysteine may substitute for methionine in the chick and can be assumed to do the same in the ruminant (Retrum, 1988). If the ruminal microbes must obtain their sulfur from cysteine rather than methionine, the degree of processing of FM must be considered. Although high temperatures break the disulfide bonds of cysteine making it available, extreme heating can render cysteine almost completely undigestible (Retrum, 1988). The increased amount of offal contained in FM can also have a negative effect on the sulfur content of the meal by decreasing the amounts of cysteine and methionine within the meal (Retrum, 1988).

Further evidence of the poor deamination of FM in the rumen is given by the fact that concentrations of branched chain fatty acids (isobutyrate, isovalerate, and valerate) were lower in the rumens of dairy cows fed rations containing FM (Waltz et al., 1989). Branched chain fatty acids are the product of amino acid degradation (Orskov, 1982). This reduction in the extent of deamination of FM in the rumen would provide a higher concentration of amino acids available for absorption in the lower tract assuming the FM is digestible. However, Waltz et al. (1989) reported that the absorption of individual amino acids, expressed as

a percentage entering the duodenum, was lower for FM than for SBM.

Performance Trials

Lower gains were observed for growing pigs fed a ration containing 7.5% FM as compared to pigs receiving SBM rations (Combs et al., 1958). McCasland et al. (1966) reported slightly lower growth rates for rats fed FM rations supplemented with methionine, lysine, histidine and tryptophan as compared to purified SBM diets. The poor amino acid profile of FM makes its inclusion into rations for monogastric species uneconomical.

However, FM has been used extensively in growing rations for ruminants. One of the first studies, utilizing FM as a supplemental protein source for ruminants, was performed by Jordan and Croom (1957). The addition of FM to lamb fattening rations supported higher daily gains, .15 vs .13 kg/d, than SBM-fed controls. Aderibigbe and Church (1983a) fed 60 cross bred wether and ewe lambs a basal diet containing ground corn and ryegrass straw. Supplemental protein was provided as control (C), CSM or hydrolyzed turkey feathers (HTF) processed at different temperatures and/or pressures ((A) 45 min @ 2.46 kg/cm^2; (B) 60 min @ 3.16 kg/cm^2; (C) 90 min @ 3.16 kg/cm^2). Average daily gain (ADG) was significantly improved for lambs receiving HTF-B and HTF-C (.02, .24, .22, .27 and .29 kg/d for C, CSM, HTF-

A, HTF-B and HTF-C, respectively). Feed efficiency (FE) was also improved for the HTF-B and HTF-C fed groups.

Many studies have evaluated the inclusion of FM in rations for growing cattle. Wray et al. (1979) conducted three experiments to determine the effects of FM on growing cattle performance. In the first study, steer calves were fed a basal ration of silage and high moisture corn and were given protein supplements containing either SBM, 19% FM or 31% FM to obtain diet crude protein levels of 38, 36 or 37%, respectively. Average daily gains (kg/d) were .98, .99 and .97 and FE (kg DM/kg gain) were 6.38, 6.35 and 6.65, respectively. In a second study with growing heifers, FM (9 and 19% additions to a corn silage and cracked corn diet) reduced FE as compared to SBM controls, although ADG was not affected by supplemental protein source. The third study utilized finishing steers consuming a high moisture ground corn ration with protein supplements of SBM and 9.5, 19 or 28.5% FM. Steers fed the highest level of FM tended to have a higher ADG (1.09, 1.08, 1.07 and 1.12 kg/d, respectively) and a greater FE (6.34, 6.36, 6.32 and 6.17 kg DM/kg gain, respectively). Church et al. (1982) fed steers a combination of urea and FM and tended to improve ADG compared to either SBM or FM supplemented animals. No differences were seen between the SBM and FM supplemented steers. Improved FE was also noted for steers fed the FM-urea supplement (7.51, 8.31 and 8.36 kg DM/kg gain for FM-urea, SBM and FM, respectively). Goedeken et al. (1990b)

fed steers a ration of 50% ground corncobs, 40% corn silage and 10% protein supplement, formulated to contain 11.5% CP. The protein sources for the supplements were SBM, FM or a combination of BM and FM. Performance of the steers receiving SBM and FM was similar, but steers fed the BM-FM supplement had significantly greater ADG (.51, .58 and .66 kg/d for the SBM, FM and BM-FM groups, respectively). Including FM in the silage diets for growing steer calves (199 kg) did not increase the performance compared to SBM controls (Harvey and Spears, 1991). The ADG for the two groups was .93 and .70 kg/d for the SBM and FM groups, respectively.

Palatability

Palatability is a major concern when including FM in protein supplements. Leme et al. (1978) reported that some lactating beef cows grazing dormant native range refused feed when 15% FM replaced SBM in their supplements. The cows in this study were group-fed and two out of 16 cows would not consume the supplement. A general trend for slower consumption of supplements containing FM was observed. Lactating dairy cattle consuming rations containing 3.5, 6.7 and 9.7% FM, were reported to have decreased concentrate consumption with increasing FM additions (Rakes et al., 1968). Decreases of 3.2, 3.9 and 6.8 kg were seen when abrupt additions of FM were made. Wray et al. (1979) reported no supplement refusals for

growing steer calves fed a basal diet of high moisture corn and corn silage even though their supplement (fed at 31.2% of intake) contained 100% FM as the protein source.

Summary Of Literature Reviewed

Advancing season and weathering greatly reduces the nutritive value of dormant grasses. Supplying protein supplements to beef cows, grazing dormant range forages, is a means of increasing N status. Increased forage intake and utilization are seen when ruminants grazing low quality forages are fed small amounts of high protein supplements (McCollum and Galyean, 1985).

Feather meal is a byproduct of the poultry processing industry and is produced by the treating of feathers with steam and/or chemicals and heat to break the strong disulfide bonds characteristic of keratin proteins. The crude protein content of FM ranges from 80 to 90% on a DM basis, but large variation in the protein quality of FM has been reported.

The poor amino acid balance of FM has limited its use in protein supplements for monogastric species, but FM has been used extensively in ruminant diets. Although the methionine content of FM is low, it has been shown that cysteine can be used to replace some of the methionine in diets for poultry, and it can be assumed that such a substitution could occur in the ruminant (Retrum, 1988).

Several growth and performance trials have been conducted utilizing FM as a supplemental protein source. Results of these studies would indicate that animal performance can be improved with FM supplementation if the ruminal protein requirements are first met by a source of degradable protein. Dairy cattle rations have also been formulated to contain FM to obtain an optimum balance of ruminal degradable and undegradable protein to attain maximum animal productivity.

The use of FM may also be hindered by the lack of animal acceptance. In several studies feed refusals were seen when FM was abruptly added to rations without some time given for adaptation. It has been recommended that supplements be pelleted if FM is to be included in the formulation.

The following trials were conducted to determine the effects of FM additions to winter supplements for beef cows grazing dormant native range. These studies utilized both lactating and dry, mid- to late gestation, beef cows consuming low quality forage. Also, the ruminally degradable fraction of the N within FM was determined by in situ incubation and the potential intestinal digestibility of N was determined by pepsin-HCl procedures.

CHAPTER III

FEATHER MEAL IN WINTER SUPPLEMENTS FOR BEEF COWS

Abstract

Seventy-six spring- and 65 fall-calving Hereford and Hereford X Angus cows were blocked by age, breed and weight, within calving season, and allotted to four groups to compare performance when 7.5 or 15% hydrolyzed feather meal (FM) replaced isonitrogenous amounts of soybean meal (SBM) in winter supplements. Cows were maintained by calving group on native range and individually fed supplements in covered stalls 6 d/wk. The supplementation period was November 14 to April 17 for spring-calving cows and November 28 to March 20 for fall-calving cows. Supplements, CP% and kg CP/d were: (1) Negative control (NC) 23% CP, .31 kg; (2) SBM, 40% CP, .54 kg; (3) 7.5% FM, 40% CP, .54 kg and (4) 15% FM, 40% CP, .54 kg. For spring-calving cows, SBM cows lost less weight ($P < .05$) precalving and for the total winter period than NC cows. Weight changes for both FM treatments were intermediate for these periods. Five percent of spring-calving cows offered 7.5% FM, and 10.5% offered 15% FM, refused to consume supplement and were

removed from the study. While ad libitum access to prairie hay was provided, fall-calving cows weight losses were greater ($P < .01$) for NC than for FM and a tendency ($P = .12$) was also observed for the NC to lose more weight than the SBM. The 15% FM cows tended ($P < .16$) to gain more weight than the SBM cows during this period. However, poorer performance was noted for the FM cows when hay was no longer provided and dormant range provided the forage. Results suggest FM may be more appropriate for supplementing on higher quality forages than on dormant range.

Introduction

Protein is one of the major costs in a cow-calf operation for winter supplementation on dormant range forages. Because the cost per unit of protein of FM is considerably less than that of traditional oilseed meals, FM may offer a way to reduce the costs of protein supplementation of wintering beef cows.

Feather meal supplementation may offer other benefits to the cow-calf producer. In growing and finishing programs for ruminants, the use of feed proteins that are high in escape or bypass potential has shown equal or increased animal performance over plant protein sources (Jordan and Croom, 1957; Wray et al., 1979; Goedeken et al., 1990a). By escaping the rumen, the proteins and amino acids are available for absorption in the small intestine. At high levels of production (ie. lactation, rapid growth) protein

requirements of animals are increased, and the rumen may not be able to supply enough microbial protein to the small intestine. Bypass protein offers a means of increasing the N status of the animal because the rumen microbes are not able to convert these proteins into microbial proteins and an increased flow of protein and amino acids to the small intestine could be seen. In late gestation and early lactation, cows may be in a state of negative N and/or energy balance. Supplemental bypass proteins may offer a means of increasing the N status of the animal by decreasing the amount of supplement fed and increasing the conversion of these supplements (McCollum and Horn, 1990).

Few studies have been conducted to investigate the use of FM in range cow protein supplements. Thus the purpose of this study was to evaluate the performance of dry pregnant and lactating cows grazing native range during the winter.

Experimental Procedure

Trial I

The value of hydrolyzed feather meal (FM) as a supplemental protein source for spring-calving beef cows grazing winter range was evaluated. Supplements, CP% and kg CP/d were (1) Negative control (NC), 23% CP, .31 kg; (2) Soybean meal (SBM), 40% CP, .54 kg; (3) 7.5% HFM, 40% CP, .54 kg; and (4) 15% HFM, 40% CP, .54 kg. Supplements provided equal daily amounts of calcium, phosphorus,

potassium, and vitamin A. Complete supplement formulations are given in TABLE I. Cows were maintained on a single pasture for the entire supplementation period. The predominant forage species were little bluestem (Andropogon scoparious), big bluestem (Andropogon gerardi), Indian grass (Sorgastrum nutans) and switch grass (Panicum virgatum). The trial was conducted at the Lake Carl Blackwell Range Cow Research Center, approximately 19 km west of Stillwater in north central Oklahoma. Cows were gathered from pasture 6 d/wk and individually fed pelleted supplements (4.8 mm) in a covered stall barn.

Samples of supplements, forage, and hay were taken initially and at 56-d intervals and analyzed for protein content (Kjeldahl N X 6.25; AOAC, 1984). Supplements were ground to pass a 2 mm screen then dried for 24 h at 65^{o}C. Forage samples were hand clipped by two technicians.

On November 14, 1989, after overnight withdrawl from feed and water, 76, 2-to-7 year old spring-calving Hereford and Hereford X Angus cows were weighed and body condition scores (BCS) evaluated. Cows were blocked by cow weight, body condition, age and breed and randomly alloted to one of the four supplemental groups.

During a 5-d adaptation period to supplements and the individual feeding facility, cattle received .91 kg of supplement/d. Following adaptation, all cows received their full amount of supplement. Supplementation continued through April 17, 1990. Ad libitum access to prairie hay

(6% CP) was allowed during times of snow cover and extreme cold (Temp < 0°C, total of 29 d).

Weights were determined initially and at 28-d intervals prepartum. Two wk prior to first expected parturition, the weighing schedule was changed to a 14-d interval with the closest weight prior to parturition being recorded as the final pregnant weight for each cow. At parturition, calf weights, breed, sex, and calving ease scores (1 = unassisted, 2 = hand pull, 3 = mechanical pull, 4 = Caesarean section, 5 = abnormal presentation) were recorded. Calves were weighed with the cows (28-d interval) during the remainder of the trial.

Body condition scores were determined initially and at 56-d intervals. Body condition scores were evaluated by two technicians and the average of the two scores recorded. Body condition scores were based on a scale of 1 to 9 with 1 = very thin and 9 = very fat (Wagner et al., 1988).

The average calving date was March 3, 1990. On May 4, three Hereford X Angus bulls were placed with all cows for 74 days. Pregnancy was determined by rectal palpation on October 18.

Estimates of milk production were obtained using the weigh-suckle-weigh technique on May 22 and July 17. Cows and calves were gathered the evenings of May 21 and July 16 and allowed to nurse, following which pairs were separated for a 12-h period. Calves were weighed the next morning, allowed to nurse until satisfied, then reweighed. Pairs

remained separated for another 12-h period then calves were weighed following the same procedure as described earlier. The two 12-h milk productions were added together to obtain an estimate of 24-h milk production. Calves were weaned on September 5. Second year calving dates were recorded to determine the time of conception for cows in each treatment, a mean gestation length of 283 d was used.

Data were analyzed by least squares ANOVA using the General Linear Models (GLM) procedure of SAS (1985). The statistical model used included treatment, breed, age, initial weight, calf birth date and the interactions treatment by breed, treatment by age and breed by age.

One cow calved early (December 28), and was removed from the study. One cow died at parturition because of uterine prolapse, and another had a still birth, thus only data prior to parturition were used for these two cows and only calf birth weights were used for analysis. One calf was discovered dead on the morning of May 9, so only data for the cow and calf prior to this date were used.

Trial II

On November 21, 1989, 65 2-to-6 year old fall-calving Hereford and Hereford X Angus cows were weighed and BCS evaluated after an overnight withdrawal from feed and water. The trial was conducted as described for Trial I with the following exceptions.

Supplementation began on November 28, 1989, and continued through March 20, 1990. Ad libitum access to prairie hay (6% CP) was allowed from December 6, 1989, until January 15, 1990. Bulls were placed with the cows for a 64-d breeding season begining on November 28, 1989.

A milk production estimate was conducted as described in Trial I on March 20, 1990. Pregnancy was determined by rectal palpation on April 26. All calves were weaned on May 1, 1990.

Data were analyzed by least squares ANOVA using the General Linear Models (GLM) procedure of SAS (1985). The statistical model used included treatment, breed, age, initial weight, initial calf weight and the interactions treatment by breed, treatment by age and breed by age.

Results and Discussion

Trial I

Spring-calving cows fed NC lost more weight ($P < .07$) from November 14 to calving than cows receiving SBM or 15% FM (TABLE II). A similar trend ($P < .17$) was also noted for cows fed 7.5% FM. No differences were seen between SBM, 7.5% FM or 15% FM during this same period ($P > .47$). The precalving weight changes observed were -4.7, 9.1, 4.4 and 8.4 kg for the NC, SBM, 7.5% FM and 15% FM supplemented cows, respectively. Precalving condition change (TABLE III) did not differ ($P > .44$) between groups.

Cow weight changes from parturition to the end of supplementation (April 17) did not differ between supplemental protein groups. Momont et al. (1990) reported that wintering spring calving beef cows consuming FM supplements performed similarly to those fed SBM supplements during early lactation. No statistical differences were seen for changes in cow BCS between treatments during the lactational phase of this study.

For the entire winter supplementation period NC cows lost more weight ($P < .05$) than did the SBM-fed cows. This is in agreement with previous work (Lusby and Wettemann, 1988) in which increasing levels of supplemental protein fed to dry pregnant cows increased performance during winter grazing. The weight changes of the 7.5% FM supplemented cows tended ($P < .15$) to be less than the NC, but were not different than the SBM supplemented cows ($P > .30$). Weight changes experienced during this period were -69.1, -53.0, -59.0 and -60.0 kg for the NC, SBM, 7.5% FM and 15% FM groups, respectively. Winter BCS changes followed the same trends as did the weight changes, with the cows losing the most weight also losing the most body condition.

Cows losing the most weight during the winter supplementation period tended to regain the most weight through the summer ($P > .12$). Weight gains were 54.1, 47.6, 66.5 and 51.6 kg for NC, SBM, 7.5% FM and 15% FM, respectively. These gains compensated for winter losses so no differences in cow weights were observed at the time of

weaning. Lusby et al. (1976) reported that cows wintered on suboptimal nutrition tended to compensate for losses when adequate nutrition was made available during summer grazing.

Body condition score changes for the summer period were significantly less for SBM than for any other treatment. Changes observed were 1.15, .81, 1.25 and 1.05 for the NC, SBM, 7.5% FM and 15% FM cows, respectively. Total body condition changes (11/14/89 to 9/06/90), were not significantly affected by the source of supplemental protein and were -.4, -.3, -.1 and -.2 for the NC, SBM, 7.5% FM and 15% FM groups, respectively.

In the present study, calf birth weights, preweaning weight gains, and weaning weights (TABLE IV) were not affected by treatments. The respective weaning weights for the NC, SBM, 7.5% FM and 15% FM groups were 200.0, 198.0, 195.4 and 200.2 kg. No differences were reported for calf gains or weaning weights for calves of cows receiving FM supplements on dormant forage when compared to SBM supplements (Momont et al., 1990). The amount of milk (TABLE II) given during the milk production trials did not differ ($P > .25$) between supplemental groups. Milk production for the two estimates taken were 7.8, 7.6, 7.7, 9.1 and 6.3, 5.6, 5.2, 6.1 kg/24h for NC, SBM, 7.5% FM and 15%FM, respectively. Rakes et al. (1968) reported no differences in milk production when dairy cows were fed rations containing FM as compared to soybean meal.

No statistical differences were seen for cow rebreeding rates between protein groups (TABLE II). Soybean meal supplemented cows had the highest pregnancy rate (86.3%) while pregnancy rates were 83.7, 82.1 and 76.5 % for NC, 7.5% FM and 15% FM fed cows, respectively. Momont et al. (1990) also observed similar percentages of cows cycling early in the breeding season, and percentages of cows pregnant when they were supplemented with either FM or SBM.

The conception interval was greater ($P < .04$) for the 7.5% FM supplemental group than for either NC or SBM fed cows (TABLE V). No difference in interval to conception was found between the two FM groups. The conception intervals were 84.1, 84.3, 100.6 and 91.3 d for NC, SBM, 7.5% FM and 15% FM, respectively.

Problems with feed consumption were experienced in the present study, with 1 out of 19 cows on the 7.5% FM treatment and 2 out of 19 cows on the 15% FM treatment refusing to eat supplements. One cow in the 15% FM group which refused to eat would only smell the supplement, suggesting that an odor is detectable even when small amounts of FM are included. Palatability problems have been a concern with FM additions to protein supplements. Rakes et al. (1968) reported a decrease in feed consumption when FM was abruptly added to lactating dairy cattle rations. The addition of FM at 3.5% of ration DM, resulted in a significant reduction in DM intake, Rakes et al. (1968) concluded that an adaptation period is required to aquaint

cattle to FM rations. Similar responses were reported by Leme et al. (1978). Dry pregnant beef cows, grazing dormant native forage and receiving protein supplements containing 15% FM, showed some feed refusals.

Trial II

Cow weight, BCS changes, milk production and pregnancy rates are given in TABLE VI. From November 28, 1989, to January 23, 1990, while ad libitum access to hay was allowed, fall-calving cows fed NC lost more weight ($P < .05$) than cows receiving either of the FM supplements and tended to lose more weight than the SBM fed cows ($P > .12$) Cows receiving 15% FM tended to gain more weight than the SBM-fed cows ($P < .16$). Weight gains were -7.5, -0.4, 4.8 and 6.1 kg for NC, SBM, 7.5% FM and 15% FM, respectively. Many studies have shown that an increase in performance with bypass proteins will not be seen until the needs for ruminal degradable protein are met (Stanton et al., 1983; Petersen, 1987; McCollum and Horn, 1990). The inclusion of supplemental hay (6% CP) along with the degradable fraction of CP in the FM supplements apparently met the ruminal N requiremants, and could explain the increased performance of the FM-supplemented cows as compared to those receiving the SBM supplement.

Once hay feeding ended on January 15 until the end of supplementation, cows fed SBM lost less weight than all other supplemental groups ($P < .04$). No statistical

differences were observed between NC and FM-supplemented cows during this time, and weight losses were -41.5, -26.1, -34.8 and -40.0 kg for NC, SBM, 7.5% FM and 15% FM supplemented cows, respectively. The low quality of the forage (2.5% CP) coupled with the poor ruminal degradability of the FM supplements (discussed in CHAPTER IV), apparently did not meet the minimum requirements for ruminal degradable N and may explain the decreased performance of the FM supplemented cows once ad libitum access to hay was denied.

The total weight loss for the entire supplementation period (November 28 to March 20) was significantly greater for the NC-supplemented cows (-49.0 vs -26.5, -30.0, -33.9 kg) than for any of the 40% CP supplements. This was evidence that protein was a limiting factor in the diet. The comparison of weight change between the 15% FM and SBM supplemented cows (-33.9 vs -26.5 kg) tended to be different ($P < .08$). Weight changes for the 7.5% FM supplemented cows were intermediate with no statistical differences found between them and the SBM or 15% FM supplemented groups. Cow BCS changes from November 28 to March 20 though not significant, tended to reflect the cow weight changes observed.

Calf gains were not affected by protein supplements (TABLE VII). Weaning weights were 142.7, 144.1, 140.6 and 146.9 kg for NC, SBM, 7.5% FM and 15% FM, respectively. This is in contradiction to other studies in which increased calf performance was seen when their dams received bypass

proteins as compared to ruminal degradable proteins (Petersen, 1987).

No differences (P > .9) were seen among treatments for milk production (2.7, 2.5, 2.9 and 2.6 kg/d for NC, SBM, 7.5% FM and 15% FM, respectively). This is in disagreement with previous work by Hibberd et al. (1988), who reported an increase in milk production during mid- to late lactation when fall calving cows received protein supplements with bypass potential as compared to SBM, but subsequent studies could not varify this result (Hibberd, personal communication). Rakes et al. (1968) reported no difference in milk production of dairy cows receiving FM supplements as compared to SBM.

Rebreeding rates ranged from 99.2% to 70.3% (P > .25). They were highest for the SBM and lowest for the 7.5% FM supplemented cows. As in Trial I no effect of protein supplement on rebreeding rate was found. Age of dam had the greatest influence on pregnancy rates.

Interval to conception was greatest (P <. 05) for the NC supplemented cows (TABLE VIII). No differences were seen for conception interval between the other three 40% CP supplements. Days from parturition to conception were 112.6, 93.1, 88.4 and 98.1 for the NC, SBM, 7.5% FM and 15% FM supplemented cows, respectively.

In contrast to palatability problems that were experienced with the spring-calving cows, no supplement refusals were noted during this study. All cows that

started the study remained on supplements throughout the feeding program.

In conclusion, the additions of FM to protein supplements did not increase the performance of either spring- or fall-calving beef cows. In fact, the performance of cows receiving FM tended to decrease with decreasing roughage protein levels. This suggests, as in previous studies with bypass proteins, that a decrease in performance is seen if too much protein bypasses the rumen and the needs for ruminal degradable protein are not met or not enough protein is bypassed to meet the animals needs.

Palatability is a major concern with the inclusion of FM in winter protein supplements. Supplement refusals were seen in the present study and in the study by Leme et al. (1978) with FM additions to protein supplements. In a production situation, removal of nonconsumers would be difficult because many nonconsuming cows would not be obvious until significant weight loss had occured. When animals are individually fed in a research environment, such removals are easily made. If the three animals which refused FM supplements in the spring-calving herd had not been removed from the study, they would undoubtedly have experienced tremendous weight and condition losses and their subsequent breeding performance would have been low. Therefore, weight and condition losses, and rebreeding rates reported in our study for FM-supplemental groups probably overestimate performance in an applied production situation.

TABLE I

COMPOSITION OF SUPPLEMENTS AND DAILY FEEDING RATES (DM BASIS)

	NC	SBM	FM 7.5%	FM 15%
Ingredients, %				
Soybean meal	43.50	90.50	73.70	58.25
Feather meal			8.00	15.50
Milo	48.45	4.00	12.00	19.00
Molasses	3.50	3.50	3.50	3.50
Dicalcium phosphate	2.70	1.90	2.10	2.50
Potassium chloride		1.75	0.60	1.15
Vitamin A[a]	0.1	0.1	0.1	0.1
CP, %	26.32	44.87	44.74	44.71
Feeding rates[b]				
kg/d	1.36	1.36	1.36	1.36
Daily CP supplied, kg	.31	.54	.54	.54

[a]6060 IU/kg.
[b]7-d basis.

TABLE II

WEIGHT CHANGES, MILK PRODUCTION AND PREGNANCY RATES OF SPRING-CALVING COWS IN TRIAL I (LEAST SQUARE MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Number of Cows					
Initial	19	19	19	19	
Final	17	19	17	16	
Initial Weight, kg					
11/14/89	459	459	459	457	
Precalving:					
Weight Change, kg					
11/14/89 - calving	-4.7[b]	9.1[c]	4.4[bc]	8.4[bc]	5.3
Postcalving:					
Weight Change, kg					
Calving - 4-17-90	-64.0	-61.9	-63.1	-68.1	5.9
Winter Gain, kg					
11/14/89 - 4/17/90	-69.1[b]	-53.0[c]	-59.0[bc]	-60.0[bc]	5.7
Summer Gain, kg					
4/18/90 - 9/06/90	54.1	47.6	66.5	51.6	7.2
Total Gain, kg					
11/14/89 - 9/06/90	-9.2	-3.5	7.2	-6.0	8.4
Milk Production, kg					
5/22/90	7.8	7.6	7.7	9.1	.6
7/17/90	6.3	5.6	5.2	6.1	.5
Pregnancy Rates %	83.7	86.3	82.1	76.5	11.6

[a]Standard Error.
[bc]Means on the same line with the same superscript do not differ significantly (P<.05).

TABLE III

BODY CONDITION CHANGES OF SPRING-CALVING COWS IN TRIAL I (LEAST SQUARE MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Number of Cows					
Initial	19	19	19	19	
Final	17	19	17	16	
Initial Condition					
11/14/89	6.0	5.9	6.0	5.9	
Precalving:					
Condition Change					
11/14/89 - calving	-.6	-.5	-.5	-.5	.15
Postcalving:					
Condition Change					
Calving - 4-17-90	-1.1	-.8	-1.0	-1.1	.13
Winter:					
Condition change					
11/14/89 - 4/17/90	-1.6[b]	-1.1[c]	-1.3[bc]	-1.3[bc]	.17
Summer:					
Condition Change					
4/18/90 - 9/06/90	1.2[b]	0.8[c]	1.3[b]	1.1[b]	.11
Total:					
Condition Change					
11/14/89 - 9/06/90	-.4	-.3	-.1	-.2	.17

[a]Standard Error.
[bc]Means on same line with the same superscript do not differ significantly (P<.05).

TABLE IV

CALF BIRTH WEIGHT, WEIGHT GAIN AND WEANING WEIGHT FOR SPRING-BORN IN TRIAL I (LEAST SQUARES MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Calf Birth Weights, kg	38.6	39.7	39.4	39.5	1.0
Calf Gain, kg					
Birth - 4/17/90	27.8	29.3	26.7	29.4	2.4
4/18/90 - 9/06/90	133.6	129.0	129.3	131.3	2.4
Weaning Weight, kg	200.0	198.0	195.4	200.2	6.8

[a]Standard Error.

TABLE V

CALVING DATES AND INTERVAL TO CONCEPTION FOR SPRING-CALVING COWS IN TRIAL I (LEAST SQUARES MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Calving date,					
1990	3/04	3/06	3/03	3/02	
1991	3/07	3/10	3/19	3/12	
Conception interval[b]					
days	84.1[c]	84.3[c]	100.6[d]	91.3[cd]	5.4

[a]Standard Error.
[b]Mean gestation of 283 days used for determination.
[cd]Means on the same line with different superscripts differ significantly ($P < .05$).

TABLE VI

WEIGHT AND BODY CONDITION CHANGES AND PREGNANCY RATES OF FALL-CALVING COWS IN TRIAL II (LEAST SQUARE MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Number of Cows	16	16	17	16	
Initial Weight, kg 11/28/89	428	430	427	429	
Weight Change, kg					
11/28/89 - 1/23/90	-7.5[b]	-0.4[bc]	4.8[c]	6.1[c]	3.2
1/24/90 - 3/20/90	-41.5[b]	-26.1[c]	-34.8[b]	-40.0[b]	3.0
Total Weight Change:	-49.0[b]	-26.5[c]	-30.0[c]	-33.9[c]	2.9
Initial BCS:	5.0	5.4	5.3	5.4	
Condition Change: 11/28/89 - 3/20/90	-1.1	-.7	-.8	-.7	.1
Milk Production, kg/24 h 3/20/90	2.7	2.5	2.9	2.6	.2
Pregnancy Rates, %	79.1	99.2	70.3	76.8	10.3

[a]Standard Error.
[bc]Means on the same line with the same superscript do not differ significantly (P<.05).

TABLE VII

CALF BIRTH WEIGHT, WEIGHT GAIN AND WEANING WEIGHT FOR FALL-BORN IN TRIAL II (LEAST SQUARES MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Calf Birth Weights, kg	36.4	36.2	36.5	34.6	1.1
Calf Gain, kg					
11/28/89 - 3/20/90	41.9	45.4	40.1	46.1	3.3
3/21/90 - 5/01/90	63.9	65.3	61.8	68.2	3.7
Weaning Weight, kg	142.7	144.1	140.6	146.9	3.7

[a]Standard Error.

TABLE VIII

CALVING DATES AND INTERVAL TO CONCEPTION FOR FALL-CALVING COWS IN TRIAL II (LEAST SQUARES MEANS)

	NC	SBM	FM 7.5%	FM 15%	SE[a]
Calving date,					
1989	10/18	10/16	10/19	10/20	
1990	11/17	10/24	10/22	11/04	
Conception interval[b]					
days	112.6[c]	93.1[d]	88.4[d]	98.1[d]	6.0

[a]Standard Error.
[b]Mean gestation of 283 days used for determination.
[c]Means on the same line with different superscripts differ significantly ($P < .05$).

CHAPTER IV

IN SITU NITROGEN AND DRY MATTER DEGRADATION AND PEPSIN DIGESTIBILITY IN VITRO OF FEATHER MEAL

Abstract

Two heifers, fitted with ruminal cannulae, were utilized to measure nitrogen (N) and dry matter (DM) degradation of three different feather meal (FM) samples [one donated (FM-A), and two purchased (FM-B and FM-C)] soybean meal (SBM) and four protein supplements. Protein supplements used and the percentage of crude protein (CP) on 90% DM basis were (1) NC, 23% CP; (2) PC, 40% CP; (3) 7.5% FM, 40% CP; and (4) 15% FM, 40% CP. Samples and supplements were incubated in the rumens for 4, 12, 16, and 24 h. Ruminal degradation of N and DM was greater ($P < .02$) for SBM than any of the FM samples across all times. Differences ($P < .008$) were also observed between FM-A and the other two FM samples at each time. Total degradation at 24 h for N was 35.1, 20.7, 5.8 and 6.8% and for DM was 55.6, 22.8, 9.6 and 8.0% for SBM, FM-A, FM-B and FM-C, respectively. Degradation between the four protein supplements was not different at 24 h, but the N degradation

of the NC supplement tended to be less ($P > .09$) at 4 h than for any other supplement and was greater ($P < .04$) than either of the FM supplements at 12 h. Dry matter disappearance was not different at any time. Pepsin N digestibility was also determined for the FM samples and protein supplements. Differences ($P < .03$) in N digestibility between all FM samples and SBM were observed and were 89.9%, 74.3%, 62.9% and 67.3% for SBM, FM-A, FM-B and FM-C, respectively. Pepsin digestibility for the PC supplement was greater than for any other ($P < .04$). Digestibility values were 90.2, 88.0, 83.1 and 76.5% for PC, NC, 7.5% FM and 15% FM, respectively. The N and DM content of FM was found to be poorly degraded within the rumen when compared to SBM and the extent of ruminal N degradation between sources of FM was highly variable. Inclusion of FM into protein supplements greatly reduced the pepsin digestibility when compared to SBM-based supplements.

Introduction

Feather meal is a byproduct of the poultry processing industry and is high in crude protein (80% to 90% on DM basis). The proteins contained within feathers are keratins and in the raw form, are poorly utilized by livestock. Treating feathers with steam and heat (hydrolyzing), or with chemicals is necessary to break the disulfide bonds, characteristic of keratin proteins, to make them available for animal usage (Church et al., 1982).

Large variation in the quality of FM found between sources has been reported. This variation is due to processing technique and the amounts of blood and offal added to the meal (Retrum, 1988). Up to 10% of the DM of FM can consist of blood which, if added before processing, will greatly reduce the quality of the end product (Goedeken et al., 1990b). Excessive heating of blood can reduce protein digestibility and the availibility of lysine and methionine (Waibel et al., 1977). Heads and feet (offal) can also be added to the feathers under modern killing procedures (Davis et al., 1961). Addition of offal will increase the fat and ash content of the meal and reduce the percentage of crude protein (Retrum, 1988).

Although the protein digestibility of FM has been found to be superior to cottonseed meal when fed in low protein complete rations to growing ruminants (Aderibigbe and Church, 1983a), limited data are available on the N digestibility of FM when included in high protein supplements for ruminants consuming low-quality roughages. The objective of this study was to compare ruminal N and DM degradation in situ and pepsin digestibility of N in vitro of FM (from three different commercial sources) to SBM. A comparison of protein supplements containing 7.5% and 15% FM to SBM-based supplements was also conducted.

Experimental Procedures

Two ruminally cannulated heifers received .45 kg/d of a SBM supplement (40% CP) and were allowed ad libitum access to prairie grass hay (6% CP) for a 10-d adaptation period. This feeding program was continued throughout the sampling period of the study.

Samples used were, three FM samples two of which were purchased (FM-B and FM-C) and one donated (FM-A) from different commercial sources, four pelleted protein supplements (NC, PC, 7.5% FM and 15% FM) and SBM used as a control. The FM source for the protein supplements was the FM-B sample. The pelleted protein supplements were ground in a Wiley mill to pass a 2 mm screen. Composition of the supplements is shown in TABLE IX.

Samples were weighed, oven dried at 60^{o} C for 24 h, then reweighed to determine DM content. Five g of the dried samples were placed into Dacron bags, measuring 5 X 10 cm, with an average pore size of 52 micrometers. Bags were tied with wire twist ties and secured to a weighted drop line.

Prior to rumen placement, bags were soaked in warm water (40^{o} C) for 20 min. Lines were placed in the rumen for one of four different incubation times (4, 12, 16 and 24 h) with three lines serving as replications of each time, for a total of 12 lines in each animal. A reverse schedule of bag placement, in which bags were placed into the rumens at different times, was followed so that all bags were removed from the rumen simultaneously to reduce variation

among bags caused by different rinsing conditions and to aid in the removal of bags from the rumen.

Upon removal, bags were rinsed with tap water until rinse water was clear. Unincubated samples (0 h) were also placed into bags and washed. Bags were hung until drip dried, then placed in a forced-air oven and dried at 50°C for 24 h, removed, and dried for 24 h at 60°C. Each bag was then weighed to determine DM content. Samples (.2 g) from each bag were removed and N analysis performed using the micro-Kjeldahl technique (AOAC, 1980). The N residue (g) was divided by the N content (g) in the bag prior to incubation to determine the percent of N remaining after exposure.

Pepsin-HCl procedures were also performed to determine the amount of potentially digestible N contained within FM and the protein supplements. Again SBM was used as a control. One g of each sample and supplement was placed in a flask along with 1 g of pepsin and 100 ml of 0.1N HCl. Flasks were swirled and then incubated in a water bath (39° C) for 20 hours. After incubation, contents were rinsed with double distilled H_2O through No. 4 Whatman filter paper to remove the soluble N fraction. Micro-Kjeldahl procedures (AOAC, 1980) were then performed on the residues to determine the amount of undigestible N contained within the samples and supplements. The amount of N remaining was subtracted from the initial N to obtain an estimate of

pepsin digestible nitrogen. Three replicates of each sample were used.

Statistical Analysis

In Situ. Data were analyzed by least squares ANOVA using the General Linear Models (GLM) procedure of SAS (1985). Data for the FM samples and SBM were analyzed seperately from the protein supplements. A mean value was obtained from the three bags of each sample or supplement at each time within each animal. The original statistical model used for the SBM and FM samples included the effects of trt and animal with the interaction of trt by animal used as the error term. A seperate analysis was performed within each different time period. Since no significant animal effect was present, only trt effects were used in the final analysis. For the protein supplements the same procedures were followed except a significant animal effect was seen a 12, 16 and 24 h, so animal effects were included in the final analysis.

Pepsin HCl. Data were analyzed by least squares ANOVA using the General Linear Models (GLM) procedure of SAS (1985). The statistical model used included only trt effects. Again, samples and supplements were seperated for analysis. Orthogonal contrasts were used to determine differences between the SBM and the FM samples and were also used for the protein supplements.

Results and Discussion

Pepsin Digestibility

The N in FM was less digestible ($P < .0001$) in pepsin-HCl than SBM-N (TABLE X). The pepsin digestibility values were 89.9, 74.3, 62.9 and 67.3% for SBM, FM-A, FM-B and FM-C, respectively. These values are lower than those of other studies with FM (Church et al., 1982; Goedeken et al., 1990a). Church et al. (1982) reported that the pepsin digestibility of FM was similar to SBM (85.4% vs 88%). Aderibigbe and Church (1983c) found that as the processing time and hydrolysis pressure of feathers increased the pepsin digestibility to a point, then had negative influences. Davis et al. (1961) reported similar increases in pepsin digestibility of N as processing times were increased while hydrolysis pressure remained constant.

The pepsin digestibility of the PC supplement was greater ($P < .05$) than for either of the FM supplements (TABLE XI). The digestibility values were 90.2, 88.0, 83.1 and 76.5% for PC, NC, 7.5% FM and 15% FM, respectivley. The lower digestibility for the supplements containing FM is in agreement with the observed lower digestibility for the FM (FM-B) used in their formulation.

Pepsin-HCl digestibility may be a good indication of protein digestibility in vivo for monogastric species, but its value for evaluating protein digestibility for ruminant species may be low (Church et al., 1982). Church et al.

(1982) reported that no correlation could be observed between the pepsin digestibility of FM and the N retention of sheep fed diets containing FM. Similarly Mehrez et al. (1980) found no correlation between pepsin digestibility of N and the disappearance of fish meal N from nylon bags in situ.

In Situ

The percentage of N and DM degradation for the FM samples is presented in TABLE X. The amount of N that was washed out at 0 h was greater for SBM than FM-A or FM-B, and variation was seen amoung FM samples. Ruminal N degradation for SBM was greater ($P < .05$) than that of FM at all times. Nitrogen disappearance was also greater ($P < .001$) for FM-A than for FM-B or FM-C across all times, but FM-B and FM-C were similar ($P > .35$) except at 4 h. The percentage of N degraded after 24 h was 35.1, 20.7, 5.8 and 6.8% for SBM, FM-A, FM-B and FM-C, respectively. Goedeken et al. (1990a) observed 12 h N degradations of 73.4% and 30.9% for SBM and FM. Miller et al. (1991) reported ruminal N disappearance for SBM and FM to be 34.1% and 11.7%, respectively, when cows were fed low quality hay (4.5% CP) and .91 kg of protein supplement. The greater N disappearance for SBM and FM reported by Goedeken et al. (1990a) could be due to the ad libitum feeding of alfalfa hay. Miller et al. (1991) observed that N disappearance from dacron bags was reduced when low-quality roughages were fed.

The DM degradation of the SBM and FM samples reflected the N disappearances observed (TABLE XI). Soybean meal had the greatest ($P < .001$) DM disappearance at all times. Large variation in DM degradation was noted for the FM samples. At 24 h the DM degradations were 55.6, 22.8, 9.6 and 8.0% for SBM, FM-A, FM-B, and FM-C, respectively.

For the protein supplements, the percentage of N degraded at 4 h tended to be less ($P < .09$) for NC than any of the 40% CP supplements, but no difference ($P > .76$) were noted amoung the 40% CP supplements (TABLE X). Low degradability may reflect the large amount of milo was in the NC supplement. At 12 h more N ($P < .05$) had been degraded from NC than either of the FM supplements. By 24 h, the N degradable amoung protein supplements was similar ($P > .48$) and the percentages of N degraded were 47.1, 47.9, 44.2 and 39.6% for PC, NC, 7.5% FM and 15% FM, respectively. Waltz et al. (1989) reported that FM additions to grain mixes reduced the amount and rate of in situ N disappearance compared to SBM. The DM disappearance for the protein supplements followed the same trends as N degradability at 4 h. No affect of supplement was observed and the 24-h DM disappearances were 63.2, 59.8, 60.7 and 58.5% for PC, NC, 7.5% FM and 15% FM, respectively.

In conclusion, N digestibility of the FM samples used in this study was highly variable. The FM sample donated by a commercial byproduct distributor (FM-A) was the highest quality meal, based on its greater N digestibility and in

situ N degradation, while those that were purchased from commercial mills (FM-B and FM-C) were of equally poor quality. A difference in the physical appearance of the meals was observed. The two purchased meals (FM-B and FM-C) had a darker and more oily appearance with large particles present. The dark color could be a reflection of over-processing or increased blood content, while the presence of large particles could be an indication of greater offal content. In both instances a lower quality product is produced because of a decreased availibility of N and amino acids and an increased fat and ash content. By the AAFCO definition, the pepsin digestibility of the CP of FM must be no less than 75%. The donated meal FM (FM-A) came very close to this requirement (74.3%), while the purchased meals were considerably lower (62.9 and 67.3% for FM-B and FM-C, respectively). Harvey and Spears (1991) reported that variatibility was a problem with FM. Although FM has been reported to be comparable to CSM or SBM as a protein source, many of these studies were conducted with FM samples that were produced in their own laboratories (Church et al., 1982; Aderibigbe and Church, 1983b; Steiner et al., 1983). Feather meal may be of equal value to plant proteins under certain processing conditions, but the large variation found in the N availability of meals, from different commercial sources, should be taken into consideration in selecting vendors of FM and in the use of FM as an ingredient in beef cattle supplements.

TABLE IX

COMPOSITION OF SUPPLEMENTS FOR IN SITU TRIAL (DM BASIS)

	NC	PC	FM 7.5%	FM 15%
Ingredients, %				
Soybean meal	43.50	90.50	73.70	58.25
Feather meal			8.00	15.50
Milo	48.45	4.00	12.00	19.00
Molasses	3.50	3.50	3.50	3.50
Dicalcium phosphate	2.70	1.90	2.10	2.50
Potassium chloride		1.75	0.60	1.15
Vitamin A[a]	0.1	0.1	0.1	0.1
CP, %	26.32	44.87	44.74	44.71

[a]6060 IU/kg.

TABLE X

PERCENTAGE OF RUMINAL N AND DM DEGRADATION IN SITU AND PEPSIN DIGESTIBILITY OF N IN VITRO OF FEATHER MEAL AND SOYBEAN MEAL (LEAST SQUARES MEANS)

	Sample				
Time, h	SBM	FM-A	FM-B	FM-C	SE[a]
		Percentage N degradation			
4	21.1[c]	17.0[d]	5.6[e]	6.4[f]	.14
12	24.0[c]	20.0[d]	9.0[e]	9.1[e]	.55
16	28.0[c]	19.5[d]	6.9[e]	8.0[e]	1.23
24	35.1[c]	20.7[d]	5.8[e]	6.8[e]	1.47
Wash out[b]	5.0[c]	0.01[d]	-0.8[d]	1.5[cd]	1.28
		Percentage DM disappearance			
4	36.9[c]	17.8[d]	7.6[e]	6.2[e]	.33
12	44.6[c]	19.3[d]	9.4[e]	6.6[f]	.55
16	48.0[c]	18.9[d]	7.5[e]	6.7[e]	.61
24	55.6[c]	22.8[d]	9.6[e]	8.0[e]	1.52
Wash out[b]	9.8[c]	3.3[d]	1.5[e]	1.2[e]	.24
Pepsin Digestibility	89.9[c]	74.3[d]	62.9[e]	67.3[f]	1.15

[a] Standard Error.
[b] Amount rinsed from unincubated bags.
[cdef] Means on the same row with same superscript do not differ ($P < .05$).

TABLE XI

PERCENTAGE OF RUMINAL N AND DM DEGRADATION IN SITU AND PEPSIN DIGESTIBILITY OF N IN VITRO OF PROTEIN SUPPLEMENTS (LEAST SQUARES MEANS)

	Supplement				
Time	PC	NC	FM 7.5%	FM 15%	SE[a]
		Percentage N degradation			
4	28.0	21.9	28.3	27.5	1.64
12	35.9[cd]	41.9[d]	32.4[c]	33.3[c]	1.71
16	38.9	41.4	35.1	33.7	1.76
24	47.1	47.9	44.2	39.6	2.18
Wash out[b]	4.8[c]	11.2[d]	3.6[c]	3.6[c]	1.74
		Percentage DM disappearance			
4	44.0	38.4	43.4	41.7	1.55
12	51.0	50.0	50.3	50.0	.91
16	55.2	52.7	53.9	51.0	1.09
24	63.2	59.8	60.7	58.5	3.38
Wash out[b]	13.5	14.1	13.5	12.4	.56
Pepsin Digestibility	90.2[c]	88.0[d]	83.1[e]	76.5[f]	.63

[a] Standard Error.
[b] Amount rinsed from unincubated bags.
[cdef] Means on the same row with same superscript do not differ ($P < .05$).

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