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FEATHER MEAL AND BLOOD MEAL AS PROTEIN SOURCES FOR BEEF CATTLE

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The high and variable cost of traditional plant proteins and poor utilization of NPN supplements when fed in combination with low quality roughages has stimulated interest in alternative protein sources. One possible source of protein for cattle feeds which has not been extensively studied is hydrolyzed feather meal. Poultry feathers are high in keratin protein (80-90%), an indigestible protein which is relatively well digested when hydrolyzed by pressure and steam heat. This hydrolyzed product will be referred to as feather meal (HFM) in the remainder of this paper. Recent interest has developed in the use of this material in the following ways:

(1) As a supplement for brood cows, particularly as a component of self-fed supplements

(2) As a source of natural protein in liquid supplements

(3) As a source of protein that is slowly degraded in the rumen

As a Supplement for Brood Cows

The lack of palatability (Jordan and Croom, 1957; Rakes et al., 1968; Thomas and Beeson, 1977) of feather meal makes it attractive in feeding situations where small quantities of supplement are needed and where the basic energy source is normally self-fed, much as with large bales or stacks of roughage and in some instances with silages.

Webster et al. (1975) compared corn silage alone, corn silage plus a 32% liquid supplement and corn silage plus a feather meal supplement for wintering lactating brood cows. The feather meal and liquid supplement were both fed free-choice. Performance of cows fed the various supplements is shown in table 1. Superior performance was obtained in regard to cow gain and cow condition with the feather meal supplement. Some difficulty was encountered in obtaining the desired consumption of feather meal. A preliminary trial with heifers had indicated that an 80% feather meal and 20% corn mixture would provide a daily crude protein intake of about one pound and that feather meal alone was not palatable. Once the trial began and the brood cows became accustomed to the feather meal-corn mixture, consumption was excessive and salt was added to decrease intake. A mixture of 45% feathermeal, 30% corn and 25% salt was used for the majority of the study. These results indicate that HFM has merit as a component of supplements which are designed to be self-fed.

Leme et al.(1978) used HFM to supply 50% of the crude protein in 15 and 40% supplements for wintering pregnant beef cows grazing dormant, native range. When compared to supplements consisting of soybean meal, gains of cows fed the HFM supplement at the 15% crude protein level were similar to the soy control but less when fed the 40% supplement containing HFM (table 2). Analysis of the 40% HFM supplement revealed that is contained 5% less protein than expected and this may have affected the results. Two of 16 cows were removed from the 40% HFM treatment for refusing to eat the supplement. Rakes et al. (1968) also observed that dairy cows were sometimes reluctant to eat when HFM was abruptly added to their concentrate.

As a Component of Liquid Supplements

Based on the satisfactory use of NPN in finishing rations, the need to reduce labor in beef cattle operations, and to avoid the cost of drying ingredients, liquid supplements consisting largely of urea, ammonium polyphosphate and molasses have been used widely in beef cattle operations since the early 1970's. Although it was well known that urea supplements provided inferior performance to natural protein sources when used to supplement rations for growing cattle and brood cows, little effort to include other natural sources of protein in liquid supplements occurred until the late seventies. Jones et al. (1976) reported that including 25% fish solubles and 25% mazoferm (fermented corn extractives) in a urea-molasses based supplement resulted in a consistent superiority over a liquid supplement containing only urea as a source of nitrogen with both high and low energy diets. Greatest improvement in nitrogen retention over the control supplement was observed when the supplement was fed with low energy Johnson grass hay rations where readily fermentable carbohydrates were not available.

More recently it has become possible to suspend water insoluble protein sources in liquid supplements through the use of attapulgite clay (Greene et al., 1979) and xanthum gum (Kelflo brand) (Perry and Mohler, 1980) (Kellems and Church, 1980). Greene et al., (1979) suspended 15% HFM in a urea-molasses based liquid supplement using 1.5% MIN-U-GEL LF (colloidal attapulgite) following the procedure of Sparks and Sawyer (1975). The suspension was prepared by using a 208 l drum as a holding tank. A centrifugal pump (2" x 2") was used for pumping and mixing the solution. While pumping the liquid supplement, HFM was added at 15% by weight of the total mixture followed by .5% formalin to aid in preservation. The mixture was then stabilized by the addition of 5.6% predispersed clay (74.25% water, .75% sodium pyrophosphate and 25% MIN-U-GEL LG). Addition of 15% HFM increased the crude protein of the supplement from 32 to 39.7%. The results of a growth trial with steers fed 11% crude protein diets consisting of cottonseed hulls and the control or HFM supplement are presented in table 3. A significant improvement in average daily gain (.2 kg) and lower blood urea nitrogen levels were observed in steers fed the HFM supplement.

Two additional studies have been conducted with growing steers fed corn silage and liquid supplement containing HFM. In one trial, forty Angus steer calves wre fed corn silage ad libitum and supplemented with the following: (1) soybean meal, (2) a 32% crude protein liquid supplement, (3) the liquid plus 15% HFM. The liquid-HFM supplement was hand fed in treatment 3 to provide similar levels of nitrogen as that provided in treatments 1 and 2, and it was also self-fed by a lick wheel feeder in treatment 4 to measure the effects of the added HFM on free choice intake. Replicate pens of five steers each were used in the 98 day feeding trial. The results are presented in table 4. Gains of cattle fed soybean meal and the liquid-HFM supplements were similar (.87 to .95) kg/day) and higher ($P<.05$) than that observed for cattle fed the control liquid supplement. Silage/gain was lowest for the soybean meal and HFM-supplement (provided free choice). When the liquid-HFM supplement was fed to provide similar levels of nitrogen as the soybean meal and control liquid, efficiency of silage utilization was less for the liquid-HFM than the soybean meal treatment, but greater than the control liquid. There did not appear to be any adverse effects of HFM on free choice intake of the liquid supplement as consumption averaged 1.8 kg/hd/day. However, efficiency of crude protein utilization, and higher BUN and rumen ammonia values were observed with cattle fed the supplement in this manner.

Wray et al. (1979) compared the nutritive value of soybean meal and supplements containing either 19 or 31% HFM. Steer calves fed corn silage-high moisture corn diets exhibited no difference in daily gains, feed efficiency, feed consumption or carcass characteristics when the levels above were used to replace soybean meal in the control supplement. Heifer calves fed corn silage, cracked corn and protein supplements containing either 9 or 19% HFM were less efficient in converting dry feed to gain than were heifers receiving a soybean meal supplement (Wray et al., 1979); however, gains and carcass characteristics were not affected. The results of the trial with the liquid-HFM supplement are in agreement with these observations.

In the previous two trials, .5% formalin was added as a preservative in preparing the HFM supplement. Since a positive response was noted with the HFM supplement over the control liquid, liquid supplements with 15% added HFM were prepared with and without formalin and evaluated in a growth trial with forty steer calves fed corn silage. The following four supplemental treatments were evaluated in an 84 day study: (1) soybean meal; (2) a 32% control liquid supplement; (3) liquid-HFM supplement; and (4) control liquid supplement plus .5% formalin. Daily silage intake was equalized among pens and each of the supplements was fed once daily at isonitrogenous levels. The results of the trial are presented in table 5. Average daily gains, efficiency of silage and crude protein utilization were superior ($P<.05$) for cattle fed soybean meal compared to those fed the liquid supplement treatments. Steers fed the HFM supplement gained .1 kg more per day and required .9 kg less silage per unit gain than those fed the control liquid supplement, but the differences were not significant ($P>.05$). All data were similar for the liquid and liquid formalin supplement which suggests that the differences observed in the two previous trials were likely due to the HFM rather than any effect of formalin on increasing ruminal protein by-pass.

Kellems and Church (1980) compared liquid supplements containing HFM or single cell protein (CSP) to a urea based supplement when fed in combination with rye-grass straw under feedlot conditions. The two supplements containing preformed proteins had 10% of their total crude protein replaced with HFM or CSP. Average daily gains (kg) for the 88 day trial were .57, .61, and .75, respectively, for the urea, SCP, and HFM treatments. The gains were not significantly different among protein sources with the small number of animals used, but greatest improvement was noted with the HFM supplement.

Perry and Mohler (1980), using xanthum gums to suspend HFM, meat and bone meal, and a combination of HFM and meat and bone meal in liquid supplements, compared these to soybean meal as a source of supplemental protein for finishing heifers. Heifers gained similarly (Table 6) on diets supplemented with soybean meal, a high urea liquid supplement, and liquid supplements containing the two preformed protein sources. Dry feed required/100 lb of gain favored the soybean meal supplemented cattle. In a second trial, Perry and Mohler (1981) evaluated the addition of 12.5% HFM to a liquid supplement when fed in both a growing and finishing situation. At the completion of the growing phase (112 days), neither the high-urea control liquid or the liquid supplement containing HFM supplemented the corn silage-corn diet as efficiently as soybean meal. Gains (lbs/day) were 2.13, 1.87, and 1.92 for soybean meal, high-urea liquid and liquid-HFM, respectively. During the 84 day finishing phase, cattle fed SBM, high urea liquid and liquid-HFM gained 2.39, 2.62 and 2.64, respectively, and as a result, gain over both phases of the trial were similar for all treatments.

In another study (Barrick and Harvey), light calves (181 kg) were used to evaluate the liquid-HFM supplement when fed with low quality (7% crude protein) pelleted Coastal bermudagrass. Two pens of five steers each were fed the following rations ad libitum: (1) pellets + soybean meal, (2) unsupplemented pellets, (3) pellets + a control 32% liquid supplement, and (4) pellets + the liquid-HFM supplement. Supplemented rations were mixed to provide ration crude protein levels of 12.6%. Results of the trial are shown in table 7. Steers fed the supplemented rations had higher feed intake and gains and more favorable feed efficiencies than those fed the pellets alone. However, there was no advantage of the HFM-supplement over the control liquid, and steers fed rations containing soybean meal gained more rapidly and more efficiently than those fed either of the liquid supplements. Another trial with similar weight calves fed Coastal bermuda pellets has shown similar results in regard to the liquid and liquid-HFM supplements.

As a Source of Slowly Degraded Protein

Recent interest has developed in animal by-products as sources of protein which are slowly degraded in the rumen. Early studies (Jordan and Jordan, 1957; Jordan and Croom, 1957) indicated no detrimental effects on performance when HFM replaced up to one half of the supplemental protein in corn-soybean meal diets for lambs. Wray et al., 1980, substituted HFM or hair meal protein for 25, 50 and 75% of the soybean meal protein in pelleted protein supplements and fed these protein sources in whole shelled corn-corncob diets to steers in three metabolism trials. Expression of the nitrogen balance data on a metabolic weight basis resulted in less urinary nitrogen excretion and higher fecal and retained nitrogen for steers fed HFM or hair meal. Rumen ammonia concentrations were higher for steers fed soybean meal than the two by-products at 1, 2, 4 and 6 hours post-feeding in two of three trials. Snyder and Harvey (1981 unpublished data) used the dacron bag technique to measure the rumen degradability of HFM and blood meal (table 8). Only about 25% of the blood meal and 30% of the HFM protein was degraded during a 24 hour period, and only 9% of the blood meal and 15% of the HFM protein was available from hours 2-24. These results in conjunction with the lower rumen ammonia values observed with HFM by Wray et al. (1980) would indicate that combining supplements of urea and by-products sources, such as HFM and blood meal may provide for more efficient utilization of nitrogen in the ruminant than with plant sources such as soybean meal. A system such as this would provide a readily available source of nitrogen for microbial growth and yet provide a source of by-pass protein.

Two feeding trials have been conducted with blood meal (ring dried) and HFM in which either 1/3 or 2/3 of the supplemental protein was supplied by either blood meal or HFM and the remainder from corn and urea. Soybean meal and a urea-corn supplement were used as controls in each study. Results of the trial with blood meal are presented in table 9 and with HFM in table 10. Cattle supplemented with the two levels of blood meal gained similarly (.70 and .71 kg/day) which was an average of .15 kg ($P<.05$) greater than that observed for cattle fed urea. Steers supplemented with soybean meal gained .78 kg/day or an average of .07 kg/day ($P>.05$) more than those supplemented with blood meal and .22 kg/day more ($P>.05$) than those provided the urea supplement. One steer on the 2/3 blood meal treatment performed very poorly (only .30 kg/day), whereas the average of the other nine steers on this treatment was .77 kg/day or similar to that of the soybean meal supplemented cattle.

Efficiency of silage and supplement utilization followed the same trends as gain. Twenty, 22 and 28% less silage was required per unit of gain for the 1/3 blood meal, 2/3 blood meal, and soybean meal, respectively, as compared to the urea treatment. Efficiency of supplement utilization was greatest for the soybean meal treatment (.54/kg of gain), but not significantly different from the .59 and .58 values observed for the 1/3 and 2/3 blood meal treatments. Other research (Stock et al., 1981, and Klopfenstein et al., 1981) has indicated that combinations of urea and blood meal exceed combinations of urea and soybean meal as protein sources for growing cattle. Gains were not significantly affected, but gain/protein ratios were improved.

The results of the trial with HFM are presented in table 9. Cattle fed the urea and urea-HFM supplements gained from .71 to .76 lb/day with no significant difference among the three treatments. Gains of cattle fed soybean meal were superior to those of the other treatments. Silage required per unit of gain was 23% less for the soybean meal supplemented cattle as compared to the average of the two feathermeal containing supplements. Similar efficiencies were noted for the HFM containing supplements and the control urea supplement. Wray et al., 1979, reported that in three feedlot trials where HFM replaced 25 to 100% of the soybean meal protein in pelleted supplements, gains were not affected, but in two of the three trials cattle fed HFM supplements required more feed per unit of gain.

The improved growth rate of cattle fed blood meal as compared to urea, and the lack of response of the HFM supplemented cattle suggest that HFM may be more resistant than blood meal to acid and enzyme break down in the abomasum and small intestine. A better balance or profile of amino acids may also be available in these sites from blood meal.

Also, responses of cattle supplemented with HFM has been somewhat variable. The reason for this is unknown but may be partially due to variability in temperatures used in processing the material.

Table 1. Influence of self-fed supplemental protein sources on lactating cows wintered on corn silage

Item	Control	Liquid	Feather Meal
No. cow-calf pairs	58	59	59
Init. cow wt., kg	423.7	429.6	430.9
Final cow wt., kg	375.1	414.1	435.9
Cow wt. change, kg	-48.5[a]	-15.4[b]	+5.0[c]
Init. weight/height, kg/cm	3.55	3.61	3.63
Final weight/height, kg/cm	3.14[a]	3.50[b]	3.66[c]
Calf avg. daily gain, kg	.36[a]	.46[b]	.49[b]

[a,b,c]Means on the same line not bearing a common superscript differ significantly (P < .05).

Table 2. Weight changes of pregnant cows supplemented with HFM and soybean meal[a]

Item	Supplements: 15% CP Soybean Meal	15% CP HFM	40% CP Soybean Meal	40% CP HFM
Supp. cow/day, lb.	2.0	2.0	2.0	2.0
Total wt. gain, lb.	1.0[d]	17.1[d]	61.8[b]	38.4[c]

[a]Adapted from Leme *et al.*, 1978
[b,c,d]Means within the same line bearing different superscripts are different (P < .05).

Table 3. Addition of 15% HFM to a liquid supplement on performance of cattle fed cottonseed hulls (59 days)

Item	Control Liquid	Liquid + HFM
Init. wt., kg	243.5	242.0
ADG, kg	.5[a]	.7[b]
Dry matter intake, kg	8.5	8.8
Supp. intake, kg	1.0	.9
BUN, mg/100 ml	23.0[a]	11.8[b]
Rumen NH_3, mg/100 ml	5.0	3.4

[a]Adapted from Greene *et al.* (1979)
[b,c]Means within the same line bearing different superscripts are different (P < .05).

Table 4. Performance, BUN, rumen ammonia concentrations in steers fed corn silage and a liquid supplement containing hydrolyzed feathermeal (HFM)

Item	Supplement			
	Soybean Meal	Liquid	Liquid-HFM	Liquid HFM (Lick-Tank)
No. animals	10	10	10	10
Init. wt., kg	179.7	181.7	180.9	180.7
Final wt., kg	272.8	255.3	266.7	274.0
ADG, kg	.95^{b}	.75^{c}	.87^{b}	.95^{b}
Daily silage, kg[a]	5.3	5.8	5.9	5.6
Silage/gain, kg	5.5	7.7^{c}	6.7^{d}	5.9^{b}
Supp. C. protein, kg	.32^{b}	.32^{b}	.32^{b}	.64^{c}
Supp. C. protein/gain, kg	.34^{b}	.43^{b}	.37^{b}	.68^{c}
BUN, mg/100 ml	4.1^{b}	8.0^{c}	6.5^{c}	15.5^{d}
Rumen NH_3, mg/100 ml	6.5^{b}	10.0^{b}	3.8^{b}	7.3^{c}

[a]Dry basis.
[bcd]Means within the same line with different superscripts differ significantly ($P < .05$).

Table 5. Performance and blood urea nitrogen concentrations of steers fed a liquid supplement with and without hydrolyzed feathermeal (HFM)

Item	Supplement			
	Soybean meal	Liquid	Liquid-HFM	Liquid + Formalin
No. animals	10	10	10	10
Init. wt/. kg	180.7	179.5	179.6	181.7
Final wt., kg	264.8	233.8	242.8	236.6
ADG, kg	1.00^{b}	.65^{c}	.75^{c}	.65^{c}
Daily silage, kg[a]	4.5	4.5	4.5	4.5
Silage/gain, kg	4.5^{b}	6.9^{c}	6.0^{c}	6.9^{c}
Supp. C. protein, kg	.32	.32	.32	.32
Supp. C. protein/gain, kg	.32^{b}	.49^{c}	.43^{c}	.49^{c}
BUN, mg/100 ml	9.6	10.1	9.5	9.7

[a]Dry basis
[b,c]Means with different superscripts within the same line differ significantly ($P < .05$).

Table 6. Performance of beef heifers supplemented with liquid supplements containing HFM and meat and bone meal[a]

Item	32% Supplements				
	Soybean Meal	All Urea	Feather Meal	Meat and Bone Meal	Feather Meal and Meat and Bone Meal
No. of cattle	23	24	24	24	24
Avg. daily gain, kg	1.00	1.00	.98	.99	.99
Feed/100 kg gain, kg	680	719	740	742	753

[a]Adapted from Perry and Mohler (1980)

Table 7. Effect of adding HFM to a urea-based liquid supplement on performance of calves fed pelleted Coastal bermudagrass

Item	Supplement			
	Soybean Meal	No Supplement	Liquid	Liquid + HFM
ADG, kg	.59	.20	.38	.31
Dry matter intake, kg	8.2	6.3	7.5	7.1
Feed/kg gain, kg	13.8	32.3	19.9	22.8

Barrick and Harvey (unpublished data)

Table 8. Ruminal protein degradation of soybean meal, blood meal and hydrolyzed feather meal (%)

Item	Ruminal Exposure (hrs)			
	2	6	12	24
Blood meal	15.3	16.8	17.7	24.5
Feather meal	14.7	19.9	23.0	29.7
Soybean meal	37.9	41.7	55.2	93.3
Corn-urea	91.3	87.7	90.4	92.0

Table 9. Performance of growing cattle fed corn silage supplemented with different combinations of urea and blood meal (112 days)

Item	Urea	Urea-Blood Meal 1/3	Urea-Blood Meal 2/3	Soybean Meal
No. animals	10	10	10	10
Init. wt, kg	225.4	223.2	221.8	221.8
Final wt, kg	287.6	302.1	301.6	308.4
Avg. daily gain, kg	.55[a]	.90[b]	.71[b]	.78[b]
Avg. daily silage, kg[c]	4.9	4.9	4.9	4.9
Feed/gain, kg				
Silage	8.80[a]	6.95[b]	6.86[b]	6.34[b]
Supplement	.75[a]	.59[b]	.58[b]	.54[b]
Supp. C.P.	.40[a]	.31[b]	.32[b]	.27[b]
Supplement C.P./analyzed, %	53.9	53.3	54.8	51.4

[ab] Means within the same line bearing different superscripts are different ($P < .05$).
[c] Dry basis.

Table 10. Performance of growing cattle (98 days) fed corn silage supplemented with different combinations of urea and hydrolyzed feathermeal (HFM)

Item	Urea	Urea-HFM 1/3	Urea-HFM 2/3	Soybean Meal
No. animals	15	15	15	15
Init. wt, kg	239.0	240.4	240.9	240.9
Final wt, kg	313.4	312.1	310.7	327.5
Avg. daily gain, kg	$.76^{a}$	$.73^{a}$	$.71^{a}$	$.89^{b}$
Avg. daily silage, kg^{c}	5.12	5.12	5.12	5.12
Feed/gain, kg				
Silage	6.49^{ab}	7.00^{b}	7.17^{b}	5.75^{a}
Supplement	$.52^{ab}$	$.57^{b}$	$.59^{b}$	$.47^{a}$
Supp. C.P.	$.25^{ab}$	$.29^{b}$	$.29^{b}$	$.24^{a}$
BUN, mg/100 ml	6.2^{a}	4.9^{a}	3.0^{b}	3.6^{b}

[ab]Means within the same line bearing different superscripts are different ($P < .05$).

[c]Dry basis.

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