

Analysis of Nutrient Composition of Feather Meal and Feather Meal with Blood

Final Report



William. H. Miner Agricultural Research Institute
P. O. Box 90, Chazy, NY 12921

K. W. Cotanch, R. J. Grant, H. M. Dann, J. W. Darrah

and



U.S. Poultry & Egg Association

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Research Organization: William. H. Miner Agricultural Research Institute

Project Leaders: Kurt Cotanch and Rick Grant
William. H. Miner Agricultural Research Institute
P. O. Box 90
Chazy, NY 12921
518-846-7121x116 (Grant)
518-846-7121x123 (Cotanch)
grant@whminer.com
cotanch@whminer.com

Co-Investigators: Charles Sniffen
Fencrest
P. O. Box 546
Holderness, NH 03245

Tom Jenkins
Clemson University
Animal/Dairy & Veterinary Sciences
Clemson, SC 29634

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INTRODUCTION

Currently, feather meal is an underutilized protein source in diets for dairy and beef cattle. A major reason for the lack of use of this product is that very little information exists regarding the nutrient content of the product. A review of the U. S. Poultry & Egg Association web site revealed little chemical composition information beyond crude protein, moisture, crude fiber, crude fat (EE), and ash analyses. The Beef and Dairy National Research Council (NRC) publications (1996; 2001) also contain incomplete chemical composition information with only one entry for feather meal. Increasingly, nutritionists use ration formulation software, such as CPM Dairy 3.0[®] for dairy diets that require complete chemical fractionation of the feed ingredient to be incorporated into the diet. Analyses required include protein fractions rumen degradable and undegradable, carbohydrate fractions (structural and nonstructural), lipid and fatty acid content, minerals, and amino acids (total protein basis and borate-phosphate buffer insoluble).

Another practical concern is the extent of variability in the feed product among plants and within a plant over time. For a nutritionist to feel comfortable using an ingredient, an accurate and representative nutrient analysis must be provided for ration formulation. It is conceivable that, in the future, further restrictions may be placed on use of ruminant-derived byproducts. If this occurs, then having accurate and complete nutrient profiles on feather meal products would position them well to compete with other protein sources in dairy and beef diets.

The approach of this research effort was to obtain samples of feather meal, and feather meal with blood where applicable, from selected plants to represent the majority of product produced in the United States. Samples were taken daily for three weeks to assess not only plant-to-plant variation, but also variation within a plant over time.

The value of this project to the poultry industry is that more complete and accurate nutrient information is now known for feather meal products, the data can now be incorporated into feed dictionaries for access by nutritionists, and use of the product should presumably increase as nutritionists have easy access to more current and detailed nutrient analyses. Also, identifying product uniformity within and between processing plants helps to improve confidence of feather meal users and or identify the need for greater control of product uniformity.

The overall objectives of this project were to:

1. Create an industry wide nutrient profile of feather meal samples representing a majority of the product produced nationally. As many as 24 poultry processing plants, representing ~85% of the feather meal produced in the US, were to be contacted through the U.S. Poultry and Egg Association for participation in this project.
2. Obtain nutrient composition data of daily feather meal production for each participating processing facility in order to identify daily product variation. The daily samples were analyzed for moisture, protein, fat and ash.
3. Obtain detailed nutrient composition profiles of weekly composite samples over three weeks for participating plants. The analyses included protein and carbohydrate fractions, fatty acid content, and amino acid profiles.

4. Provide the nutrient composition data to the individual cooperating plants and the U.S. Poultry and Egg Association.
5. Incorporate the nutrient composition profiles into the CPM Dairy 3.0[®] feed dictionary.
6. Publish an article in Feedstuffs as a means to provide nutrient composition data to field nutritionists.

METHODS AND MATERIALS

Member plants of the U.S. Poultry and Egg Association were contacted for participation in this project. Eighteen plants submitted samples for analysis. The dataset was narrowed to 16 plants due to some incomplete sample sets. Of those 16 plants considered for statistical evaluations, one plant producing a unique product was not used for comparisons with the remaining feather meal with or without blood products. As a note, we did have difficulty receiving international samples having to cross borders.

List of the 18 cooperating processing plants:

- a. American Proteins, Inc. – 3 plants (Hanceville, AL; Cuthbert, GA; Cumming, GA)
- b. Central Bi-Products – 1 plant (Redwood Falls, MN)
- c. Central Industries – 1 plant (Forest, MS)
- d. Fieldale Farms – 1 plant (Toccoa, GA)
- e. Foster Farms – 1 plant (Livingston, CA)
- f. Gold Kist, Inc. – 2 plant (Ball Ground, GA; Sumter, SC)
- g. Perdue Protein – 1 plant (Lewiston, NC)
- h. Pilgrim's Pride Corporation – 4 plants (Mt. Pleasant, TX; Broadway, VA; Moorefield, WV; Farmerville, LA)
- i. Premium Protein Products – 1 plant (Russellville, AR)
- j. River Valley Animal Foods – 2 plants (Robards, KY; Noel, MO))
- k. Simmons Foods – 1 plant (Southwest City, MO)

Sample collection

A representative sample of each day's production of feather meal was collected at each plant by an employee for five consecutive days. The daily samples collected at each plant were ~0.5 kg (1 lb) of air-dry product, sealed in a plastic sample bag, and carefully labeled with date of collection, plant identification, and type of sample (feather meal or feather with blood). A survey/data form was submitted with each set of five daily samples (appendix A) identifying the product type; feather meal or feather meal with blood, and whether blood was added pre or post hydrolyzation. Processing information included heating time, temperature and pressure; percent blood added and batch versus continuous flow processing was also recorded. This information was to be used to correlate possible effects of processing on ruminal dry matter (DM) degradation. The five daily samples were sent to the Miner Institute for analyses of moisture, protein, fat and ash to determine daily variation within the product by processing plant. These five samples were then composited by volume to create a single week's sample. This was done

for three consecutive weeks to result in three composite samples (a total of 15 daily samples for each plant). The weekly composite samples were logged into a database, sub-sampled and distributed to the cooperating laboratories. Sub-samples of the weekly composite samples were frozen and retained at the Miner Institute.

Daily sample analyses

The daily samples from each plant were analyzed for DM, Crude Protein (CP), fat and ash at the Dairy One Forage Laboratory (Ithaca, NY). The reference methods are as follows: dry matter at 105°C (method 930.15), crude protein by Kjeldahl (CP; method 990.03), fat by ether extract was measured using the automated Tecator Soxtec System HT6 (Application note AN 301; FOSS North America, Eden Prairie, MN, USA), and ash by combustion at 600°C for 2 hours (method 942.05) were determined according to the Association of Analytical Communities (AOAC) methods (2000).

Feather meal product density measurement was conducted at Miner Institute for each of the daily samples. Approximately 150 g of product was placed in a 500 ml graduated cylinder and firmly tamped downward 10 times on a counter top to settle the contents. Sample mass and volume (ml) were recorded to calculate density (lbs/ft³).

Weekly composite analyses

An 80 ml (1/3 cup) sub-sample was taken from each daily sample by week to generate the weekly composite. Weekly composite samples (3/plant) were sent to Dairy One and analyzed for the complete Cornell Net Carbohydrate and Protein System (CNCPS) nutrient profile, which for animal by-products include: DM, CP, soluble protein (SP), acid detergent insoluble crude protein (ADICP), neutral detergent insoluble crude protein (NDICP), fat, ash, starch, sugar, non-structural carbohydrates (NSC), total digestible nutrient (TDN), net energy lactation (NEL), net energy maintenance (NEM), net energy growth (NEg), metabolizable energy (ME), digestible energy (DE), calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), molybdenum (Mo), sulfur (S), and chloride (Cl). As acid detergent fiber (ADF), neutral detergent fiber (NDF) and non-fiber carbohydrate (NFC) are measurements dependent on fiber as cellulose, they are not included in the analysis of animal tissue products. The ADF and NDF procedures are, however, used to determine the respective protein fractions associated with those “fiber” fractions for animal tissue products. Methods for the listed analytes are as follows: DM (method 930.15), CP (method 990.03), and ash (method 942.05) were determined according to AOAC (2000) methods. Soluble protein was determined with a sodium borate, sodium phosphate buffer procedure (Roe and Sniffen, 1990). NSC and sugars were determined by the procedures of Hall et al. (1999) and Smith (1969) where ferricyanide was used to detect reducing sugars. Starch was determined with a YSI 2700 SELECT biochemistry analyzer (Application note 319; YSI Incorporated, Yellow Springs, Ohio, USA). NDICP and ADICP were determined by analyzing apparent NDF (aNDF) and ADF residues for Kjeldahl nitrogen (N) (Licitra et al., 1996).

The ADF residue, and aNDF residue (using α -amylase without sodium sulfite) were generated using the ANKOM A²⁰⁰ Fiber Analyzer filter bag technique (ANKOM Technology Corp.,

Fairport, NY) (Van Soest et al., 1991). Ether extract was measured using the automated Tecator Soxtec System HT6 (Application note AN 301; FOSS North America, Eden Prairie, MN). Ca, P, Mg, K, Na, Fe, Zn, Cu, Mn, and Mo were measured using a Thermo Jarrell Ash IRIS Advantage Inductively Coupled Plasma Radial Spectrometer (model ICAP 61; Thermo Jarrell Ash, Ithaca, NY) (Sirois et al., 1994). Sulfur was measured using an elemental analyzer (Application note form 203-601-229, 08/92; model SC-432; LECO Corporation, St. Joseph, MI) (Sirois et al., 1994). The chloride ion was measured using a potentiometric titrator (Application bulletin 130; Brinkmann Metrohm 716 Titrino titration unit with silver electrode; Brinkmann Instruments, Inc., Westbury, NY).

Fatty acid and total lipid analysis was conducted by Dr. Tom Jenkins at Clemson University using the method of Sukhija and Palmquist 1988 (J. Agric. Food Chem. 36:1202).

Amino acid analyses were conducted on the CP and the borate-phosphate buffer insoluble protein fraction of the weekly composite samples. These assays were conducted by the Rumen Fermentation Profiling Lab (RFPL) at West Virginia University (Morgantown, WV) in conjunction with the University of Missouri (Columbia, MO). Amino acids were determined using a standard protein hydrolysate method (AOAC Official Method 982.30 E (a), CHP.45.3.05, 1995).

In situ dry matter degradation was determined on five samples of feather meal and five samples of feather meal with blood as an initial estimate of protein degradation across the various feather meal products and processing methods. The ten samples were chosen to best represent the variability of products (feather meal without blood, or with blood added pre-or post- hydrolyser) and to encompass hydrolyzation methods including heat, pressure and time. Processing methods were defined as high heat/long time (HL), high heat/short time (HS), low heat/long time (LL), low heat/short time (LS) and lastly high heat/high pressure (HH). Rumen incubation times were 0, 4, 8, 16, 24, and 48 hours. Residues were assayed only for DM disappearance by which CP degradation was inferred. Given the nature of feather meal being nearly 80-90% CP, DM degradation was believed to represent CP degradation. A single mid-lactation cannulated cow consuming ~ 52 lbs of DM/day was used for the incubation.

Statistical Data analysis

Statistical computations were performed using the Statistical Analysis System (SAS) (version 8.2; SAS Institute Inc., Cary, NC). Data were subjected to analysis of variance using the MIXED procedure of SAS (Littell et al., 1996). Nutrient composition (DM, CP, fat, ash, and density) of daily samples was used to determine within and between plant variation. Individual plants were analyzed for within plant variation. The model included the effects of week and day. Variation among plants was analyzed and the model included plant and day. Nutrient composition (DM, CP, fat, ash, fatty acids, and amino acids) of weekly composite samples were used to determine differences between feather meal categories (no blood vs. blood; no blood vs. pre blood, vs. post blood). Significance was declared at $P < 0.05$.

The CORR procedure of SAS was used to determine Pearson correlation coefficients for density with DM, CP, fat, and ash from the daily sample dataset. Correlations were considered to be significant when $P < 0.01$.

RESULTS AND DISCUSSION

Within Processing Plant Daily Variation

Results of the daily sample analyses for each plant have been provided to the U.S. Poultry and Egg Association for distribution to each of the participating processing plants. Presented here are the results for product variability within and between plants and the nutrient profiles of the weekly composite samples. Tables 1-16 display the nutrient analyses of the daily feather meal samples for each processing plant. Plant identification is encoded by plant number, and a master list of plant IDs has previously been provided to the U.S. Poultry and Egg Association. The means and standard error of the mean values for the 15 samples are shown along with the P -values for week and day. A significant week or day effect is indicated by $P \leq 0.05$. For instance, Table 2, plant 7 shows a significant week effect for protein and ether extract indicating that across the three sampling weeks, protein and fat varied, but did not have a significant day within week effect. Nine of the 16 plants showed a week effect for nutrient composition. There were 6 plants that showed a week effect for CP, 1 for fat, 2 for DM, 4 for ash and 2 for product density. Plant 13 had a high degree of product variability across weeks for DM, CP, ash and density. There was little to no significant variation of product nutrient profile by day, except for plants 13 and 22. Again, the lack of a significant day effect indicates only that the variation by day within each week was random and that there was no trend for certain day's production to differ from others. The cause for these week effects should be investigated at each processing plant. Is there variability of the raw product received by the plant resulting in end product variation? Is the level of blood inclusion consistent across days and weeks? Are there processing factors accounting for compositional differences across weeks? The importance of identifying and controlling the factors resulting in the nutritional variation of end-product cannot be overstated considering the impression that feather meal is an inconsistent product. Clearly some plants have more consistent product than others.

A quick look at the standard error of the mean (SEM) values across plants indicates the variance of values around the mean. The larger the SEM, the greater the product variation. Smaller SEM values indicate a more consistent nutrient profile.

Table 1. Nutrient composition of feather meal from plant 6.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	95.1	0.49	0.53	0.16
Crude protein, %	89.9	0.40	0.70	0.72
Ether extract, %	8.9	0.45	0.07	0.39
Ash, %	2.0	0.06	0.15	0.36
Density, lb/ft ³	37.2	1.22	0.97	0.26

Table 2. Nutrient composition of feather meal from plant 7.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	93.2	0.56	0.53	0.53
Crude protein, %	89.0	0.74	0.05	0.81
Ether extract, %	7.5	0.25	0.05	0.19
Ash, %	2.7	0.14	0.53	0.19
Density, lb/ft ³	38.3	0.85	0.71	0.23

Table 3. Nutrient composition of feather meal from plant 8.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	91.2	0.35	0.45	0.87
Crude protein, %	87.2	1.02	0.12	0.07
Ether extract, %	9.6	0.55	0.57	0.08
Ash, %	2.3	0.07	0.16	0.62
Density, lb/ft ³	37.7	0.62	0.15	0.20

Table 4. Nutrient composition of feather meal from plant 9.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	92.7	0.53	0.43	0.74
Crude protein, %	90.5	1.14	0.35	0.34
Ether extract, %	6.1	0.25	0.38	0.78
Ash, %	1.6	0.03	0.41	0.30
Density, lb/ft ³	43.7	0.50	0.95	0.24

Table 5. Nutrient composition of feather meal from plant 10.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	91.4	0.43	0.02	0.27
Crude protein, %	92.0	0.66	0.04	0.54
Ether extract, %	6.2	0.37	0.22	0.48
Ash, %	2.0	0.12	0.47	0.93
Density, lb/ft ³	31.3	0.69	0.95	0.61

Table 6. Nutrient composition of feather meal from plant 11.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	93.4	0.19	0.96	0.93
Crude protein, %	85.9	0.45	0.03	0.34
Ether extract, %	11.3	0.34	0.05	0.36
Ash, %	3.5	0.11	0.54	0.15
Density, lb/ft ³	43.8	0.54	0.16	0.84

Table 7. Nutrient composition of feather meal from plant 13.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	93.5	0.16	0.01	0.46
Crude protein, %	88.6	0.62	0.01	0.33
Ether extract, %	9.8	0.21	0.51	0.68
Ash, %	2.4	0.09	<0.01	0.03
Density, lb/ft ³	31.9	0.53	<0.01	0.02

Table 8. Nutrient composition of feather meal from plant 14.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	90.4	0.28	0.28	0.74
Crude protein, %	86.8	0.71	0.15	0.46
Ether extract, %	10.9	0.16	0.99	0.36
Ash, %	1.9	0.04	0.10	0.26
Density, lb/ft ³	36.8	0.36	0.89	0.57

Table 9. Nutrient composition of feather meal from plant 15.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	31.8	0.19	0.27	0.79
Crude protein, %	89.6	0.75	0.09	0.99
Ether extract, %	9.0	0.14	0.84	0.42
Ash, %	2.8	0.14	0.52	0.69
Density, lb/ft ³	28.1	0.32	0.22	0.74

Table 10. Nutrient composition of feather meal from plant 18.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	97.4	0.43	0.58	0.007
Crude protein, %	85.9	0.95	0.02	0.83
Ether extract, %	10.2	0.79	0.32	0.68
Ash, %	2.3	0.10	0.39	0.78
Density, lb/ft ³	38.0	1.06	0.13	0.27

Table 11. Nutrient composition of feather meal from plant 19. (Not included in between plant statistical analysis.)

Item	Mean	SEM	<i>P</i> -value	
			Week	Day
Dry matter, %	95.1	0.51	0.71	0.6
Crude protein, %	71.2	1.09	0.22	0.82
Ether extract, %	20.5	0.83	0.98	0.53
Ash, %	7.2	0.13	0.01	0.41
Density, lb/ft ³	38.6	1.56	0.58	0.68

Table 12. Nutrient composition of feather meal from plant 21.

Item	Mean	SEM	<i>P</i> -value	
			Week	Day
Dry matter, %	91.8	0.29	0.09	0.72
Crude protein, %	84.1	0.93	0.15	0.89
Ether extract, %	14.8	0.84	0.70	0.85
Ash, %	1.5	0.67	0.34	0.97
Density, lb/ft ³	37.5	0.37	0.14	0.86

Table 13. Nutrient composition of feather meal from plant 22.

Item	Mean	SEM	<i>P</i> -value	
			Week	Day
Dry matter, %	91.1	0.29	0.38	0.88
Crude protein, %	87.9	0.39	0.27	0.46
Ether extract, %	10.4	0.25	0.83	0.08
Ash, %	2.3	0.07	0.02	0.01
Density, lb/ft ³	38.3	0.54	0.13	0.46

Table 14. Nutrient composition of feather meal from plant 23.

Item	Mean	SEM	<i>P</i> -value	
			Week	Day
Dry matter, %	96.8	0.32	0.18	0.61
Crude protein, %	87.1	0.58	0.50	0.95
Ether extract, %	10.4	0.22	0.59	0.99
Ash, %	2.1	0.10	0.05	0.62
Density, lb/ft ³	39.2	1.25	0.36	0.34

Table 15. Nutrient composition of feather meal from plant 24.

Item	Mean	SEM	<i>P</i> -value	
			Week	Day
Dry matter, %	93.8	0.25	0.41	0.86
Crude protein, %	88.0	0.98	0.35	0.47
Ether extract, %	9.1	0.35	0.13	0.20
Ash, %	2.2	0.10	0.17	0.53
Density, lb/ft ³	36.3	1.34	0.001	0.94

Table 16. Nutrient composition of feather meal from plant 25.

Item	Mean	SEM	P-value	
			Week	Day
Dry matter, %	96.0	0.30	0.63	0.11
Crude protein, %	84.6	0.41	0.29	0.73
Ether extract, %	10.6	0.23	0.74	0.75
Ash, %	3.7	0.07	0.59	0.83
Density, lb/ft ³	27.9	0.99	0.11	0.56

The same data for DM, CP, fat, ash, and density for all 15 daily samples for each plant are presented in Table 17 in order to determine between plant variation. As indicated by $P \leq 0.05$ for each analyte, there is a significant effect of processing plant on feather meal nutrient composition. This is to be expected considering that processing plants are producing feather meal with varying amounts of blood inclusion. Clearly feather meal product needs further delineation. There was no significant effect by day except for product density and no significant interaction effect of plant \times day. For comparative purposes, the data in Table 17 has been grouped by similar feather meal product, either with or without blood.

Of note is the range of average values for DM (90.4%-97.4%), CP (84.1%-92.0), fat (6.1%-14.8%), ash (1.5%-3.6%) and density (28.1-43.7 lbs/ft³). There is clearly considerable variation in nutrient composition between plants, even those producing similar feather meal product. The density measurement was rather crude and at times subject to judgment. In some cases, where sample size was limiting (less than 0.5 lb), we had to scale down our technique to accommodate the small sample without sacrificing the ability to determine volume using a graduated cylinder. Settling the contents in the cylinder was rather subjective, though there did seem to be a point where volume did not continue to decrease. At that point weight and volume were recorded. Conversations with some of the industry people that monitor product density indicated that it is common to use a 1 cubic foot box filled with product and then dropped to settle the contents and then filled to the top again with weight recorded as lbs/cubic foot. Density values of 34-36 lb/ft³ were said to be typical of batch cooked feather meal and about 28 lb/ft³ for continuous flow cooked feather meal. The density values obtained in this study agree with industry standards, with batch cooked feather meal averaging 37.5 lb/ft³ and continuous flow cooked feather meal averaging 35.0 lb/ft³.

Table 17. Nutrient composition of feather meal for plants (between plant variation)

Item	Plant															SEM	P-value		
	6	9	14	15	21	23	7	8	10	11	13	18	22	24	25		Plant	Day	Plant x Day
Dry matter, %	95.1	92.7	90.4	91.8	91.8	96.8	93.2	91.2	91.4	93.4	93.5	97.4	91.1	93.8	96.2	0.46	<0.001	0.32	0.29
Crude protein, %	89.9	90.5	86.8	89.6	84.1	87.1	89.0	87.2	92.0	85.9	88.6	85.9	87.9	88.0	84.7	1.21	0.001	0.41	0.56
Ether extract, %	8.9	6.1	10.9	9.0	14.8	10.4	7.5	9.6	6.2	11.3	9.8	10.2	10.4	9.1	10.7	0.53	<0.001	0.44	0.73
Ash, %	2.0	1.6	1.9	2.8	1.5	2.1	2.7	2.3	2.0	3.5	2.3	2.3	2.3	2.2	3.6	0.12	<0.001	0.29	0.57
Density, lb/ft ³	37.2	43.7	36.8	28.1	37.5	39.2	38.3	37.7	31.3	43.8	31.9	38.0	38.3	36.6	28.9	1.25	<0.001	0.03	0.37

Plants 6, 9, 14, 15, 21 and 23 produce feather meal without blood

Plants 7, 8, 10, 11, 13, 18, 22, 24 and 25 produce feather meal with blood

Weekly Composite Sample Nutrient Profile

The Dairy One CNCPS nutrient profile data is tabulated in Table 18 by feather meal category, either with blood or without blood. Statistical significance was determined by product category and by week as well as product category by week interaction. The inclusion of blood significantly affected the ash and mineral composition of feather meal. Feather meal with blood had a greater ash content with Cl, K, Na, and Fe all being significantly greater compared to feather without blood. Acid detergent CP expressed as a percent of total CP or DM was significantly lower for feather meal with blood. This indicates the relative availability of protein from blood. Generally acid detergent CP is indigestible in the ruminant animal. There was a significant effect of week across the two products concerning protein fractions. CP, SP, NDICP and ADICP as percent of CP and DM, had significant week effects. This product variability can be frustrating to nutritionists that use feather meal for specific protein requirements in ruminant nutrition. A better understanding of why this variability occurs may lead to better quality control and more consistent nutrient profiles.

The original review of the data, presented at the 2004 annual meeting of the Poultry and Egg Association in Lexington, KY, had distinguished between blood added pre- and post-hydrolyzation. It was subsequently determined that the nutritional profile, as determined with the CNCPS analyses, of feather meal with blood did not differ as a result of whether blood was added pre- or post-hydrolyzation. However, as will be discussed, this does not imply that hydrolyzation does not affect protein fractions regarding ruminal degradation and small intestinal digestibility.

Table 18. CNCPS nutrient analysis of feather meal with and without blood by Dairy One.

Item	Feather Meal Category		SEM	P-value		
	No blood	Added blood		Category	Week	Category x Week
Dry matter, %	93.3	93.5	0.94	0.88	0.43	0.04
Crude protein, %	87.8	87.7	1.07	0.96	<0.01	0.40
Ether extract, %	10.0	9.5	0.92	0.65	0.28	0.58
Ash, %	1.9	2.6	0.22	0.04	0.90	0.08
SP, %	7.4	10.0	1.40	0.18	<0.01	0.74
NDICP, % CP	49.9	51.2	4.00	0.79	<0.01	0.88
ADICP, % CP	26.5	18.9	2.67	0.05	<0.01	0.64
Ca, %	0.54	0.51	0.075	0.79	0.10	0.37
P, %	0.34	0.39	0.031	0.21	0.03	0.45
Mg, %	0.03	0.04	0.002	0.37	0.04	0.16
Cl ion, %	0.17	0.33	0.042	0.01	0.78	0.61
K, %	0.13	0.21	0.023	0.01	0.37	0.55
Na, %	0.11	0.24	0.032	<0.01	0.73	0.78
S, %	1.78	1.71	0.085	0.72	0.01	0.66
Cu, ppm	11	11	2.5	0.89	0.75	0.66
Fe, ppm	239	607	105	0.02	0.33	0.15
Mn, ppm	7	7	1	0.75	0.44	0.50
Zn, ppm	87	83	2.7	0.27	0.01	0.29
ADICP, %	23.2	16.4	2.30	0.04	<0.01	0.59
NDICP, %	44.0	44.7	3.60	0.87	0.02	0.82
NSC, %	1.9	2.0	0.12	0.40	0.15	0.25
TDN, %	82.4	81.1	1.40	0.50	0.06	0.77
NEL, Mcal/lb	0.92	0.90	0.021	0.53	0.16	0.62
NEM, Mcal/lb	0.98	0.96	0.024	0.53	0.12	0.69
NEG, Mcal/lb	0.68	0.66	0.021	0.53	0.15	0.74
Avail protein, %	64.6	71.3	2.65	0.07	<0.01	0.76
Adj CP, %	65.6	72.3	2.64	0.07	<0.01	0.76
Starch, %	0.7	0.6	0.09	0.57	0.55	0.10
Sugar, %	1.2	1.4	0.081	0.10	0.17	0.89
Mo, ppm	0.5	0.6	0.10	0.43	0.02	0.81

The amino acid profiles of the buffer insoluble residue (BIR) for feather meal with and without blood are presented in Table 20. It should first be noted that these analyses were conducted at the RFPL and that there is duplication of some of the analyses conducted by Dairy One. Both labs analyzed for DM, CP and SP, see Table 19.

Table 19. Comparison of CP and Sol P analyses of same Feather meal samples by Dairy One and RFPL.

	No Blood	No Blood	Blood	Blood
	Dairy One	RFPL	Dairy One	RFPL
CP, %DM	87.8	86.0	87.7	85.4
SP, %CP	7.4	5.8	10.0	8.3

Crude protein is nearly 2 units lower as analyzed by RFPL compared to Dairy One. Soluble protein is also about 2 units lower as analyzed by RFPL compared to Dairy One, though the relative differences between the two products are similar between the labs. Crude protein is nearly similar between the two products as determined by the labs, and a nearly identical difference of 2.5 units in soluble protein between the feather products was also determined by both labs. The composite samples received by each of the three labs, including Clemson University for fatty acids, came from the same composite sample and should be considered identical. Differences in lab analysis are likely due to minor differences in analytical procedures. As a general rule, it is best to choose a reputable lab when analyzing feeds over time. In this way, relative comparisons can be made if the analyses are consistently from the same lab. In this way, “lab” is controlled as a variable when comparing results.

There is clearly a difference in protein and amino acid profiles between feather meal with and without blood. Crude protein is similar for feather with and without blood (85.4% vs. 86.0%) while soluble protein as percent of CP is greater for feather meal with blood than without blood, (8.3% vs. 5.8%). Feather meal with blood had significantly higher levels of aspartate (Asp), alanine (Ala), methionine (Met), leucine (Leu), tyrosine (Tyr), phenylalanine (Phe), histidine (His) and lysine (Lys) as percentage of the total amino acids (TAA) recovered from the buffer insoluble residue. Feather meal without blood had significantly higher levels of serine (Ser), proline (Pro), glycine (Gly), arginine (Arg) and tryptophan (Trp). Significant differences by week were observed for insoluble CP, Ser, glutamic acid (Glu), Ala, Phe, ornithine and Trp.

The biological significance of these amino acid profile differences will depend on the animals being fed the product. In the case of dairy cattle where diets are often times limiting in methionine, lysine and histidine, the use of feather meal with blood may be more advantageous than feather meal without blood. Of course the level of feather meal inclusion in the diet and the small intestinal digestibility of the rumen undegraded protein will have significant impact on the total grams of amino acid available.

The BIR amino acid profile is used in ruminant nutrition to predict the flow of amino acids occurring as rumen undegradable protein to the lower gut. Various types of proteins differ in their rumen solubility and degradability thereby resulting in a different profile of amino acids flowing the lower gut than occurs in the original feedstuff. As feather meal is a product that has significant use in non-ruminant nutrition, expression of the amino acid profile as occurs in the original feedstuff is required. The amino acid profile of the original intact sample is presented in Appendix B. There were minor differences in the amino acid profiles of the buffer insoluble residue values compared those of the original sample.

Table 20. Amino acid profile of the borate-phosphate buffer insoluble residue (BIR) of feather meal with and without blood.

Item	Feather Meal Category		SEM	P-value		
	No blood	Added blood		Category	Week	Category x Week
Dry matter, %	94.7	95.1	0.90	0.70	0.68	0.01
Crude protein, %	86.0	85.4	0.89	0.61	0.53	0.50
Insoluble CP, %	81.0	78.2	1.14	0.09	0.06	0.66
Insoluble CP, % CP	94.2	91.7	0.94	0.06	0.14	0.14
Soluble CP, % CP	5.8	8.3	0.94	0.06	0.14	0.14
Taurine, % TAA	0.01	0.02	0.01	0.37	0.99	0.83
Hydroxyproline, % TAA	0.04	0.05	0.02	0.75	0.76	0.68
Asp, % TAA	6.49	6.81	0.049	<0.01	0.63	0.44
Thr, % TAA	4.58	4.60	0.029	0.63	0.13	0.83
Ser, % TAA	10.29	9.17	0.171	<0.01	0.05	0.54
Glu, % TAA	10.03	9.99	0.103	0.75	<0.01	0.05
Pro, % TAA	10.01	9.34	0.134	<0.01	0.64	0.80
Lanthionine, % TAA	1.53	1.49	0.161	0.84	0.91	0.37
Gly, % TAA	7.48	7.01	0.062	<0.01	0.67	0.61
Ala, % TAA	4.38	4.70	0.059	<0.01	0.07	0.96
Cys, % TAA	5.47	5.15	0.33	0.46	0.79	0.52
Val, % TAA	7.54	7.56	0.065	0.86	0.36	0.72
Met, % TAA	0.70	0.77	0.026	0.05	0.50	0.06
Ile, % TAA	4.80	4.79	0.027	0.78	0.77	0.52
Leu, % TAA	8.21	8.54	0.058	<0.01	0.10	0.79
Tyr, % TAA	2.81	2.91	0.030	0.01	0.38	0.36
Phe, % TAA	4.91	5.10	0.044	<0.010	<0.01	0.67
Hydroxylysine, % TAA	<0.01	<0.01	0.001	0.27	0.24	0.24
His, % TAA	0.74	1.28	0.065	<0.01	0.52	0.44
Ornithine, % TAA	0.43	0.43	0.028	0.97	<0.01	0.57
Lys, % TAA	2.12	2.90	0.110	<0.01	0.82	0.42
Arg, % TAA	6.88	6.73	0.029	<0.01	0.50	0.62
Trp, % TAA	0.57	0.66	0.036	0.05	<0.01	0.99

Fatty acids C16 and tC18:1 were significantly greater in feather meal with blood. Feather meal without blood had a significantly higher proportion of unsaturated C18:2 and C18:3, compared to feather meal with blood. The biological significance of these differences is minimal in dairy cattle diets. Assuming a high feeding level of 454g (1 lb) of feather meal/cow/day equates to 35.4 g of fatty acid (454g feather x 10% EE x 78% FA/EE). In the case of C18:2 that differs less than 3% between feather meal with and without blood, the difference would be only 1g of fatty acid. The significance for non-ruminants where feeding levels may be proportionally greater, needs to be considered by nutritional experts for the given species.

Interestingly, feather meal with and without blood have similar levels of fatty acid as a percentage of ether extract. Given the expense and time involved in fatty acid analyses, this

dataset can be used to fairly accurately predict fatty acid profiles of a feather meal product given the less expensive and rather quick analysis of fat as ether extract. As noted in Table 21, fatty acids comprise about 78% of the ether extract regardless of feather meal product.

Table 21. Fatty acid (FA) profile of feather meal with and without blood conducted at Clemson University for CPM 3.0.

Item	Feather Meal Category		SEM	P-value		
	No blood	Added blood		Category	Week	Category x Week
C12, % TFA	0.34	0.35	0.034	0.74	0.06	0.80
C14, % TFA	1.09	1.06	0.049	0.60	0.02	0.94
C16, % TFA	24.33	25.35	0.286	0.02	0.73	0.38
C18, % TFA	8.27	8.93	0.386	0.21	0.56	0.58
tC18:1, % TFA	1.09	1.65	0.170	0.02	0.59	0.93
C18:1, % TFA	32.51	31.98	0.646	0.54	0.30	0.52
C18:2, % TFA	13.19	10.43	0.654	<0.01	0.94	0.41
C18:3, % TFA	0.54	0.34	0.045	<0.01	0.79	0.64
Other, % TFA	18.66	19.91	0.698	0.19	0.62	0.43
FA as % EE	78.47	77.06	2.263	0.64	0.04	0.85
Total mg Fatty acid Per Gram of Sample as Received	72.90	67.79	6.460	0.55	0.09	0.52

In situ DM Degradation

The *in situ* DM degradation curves are presented in Figure 1. As noted earlier, DM degradation was quantified and CP degradation was inferred from the DM data. Ten samples were chosen to best represent feather meal with or without blood and to cover the variety of hydrolyzation specifications including temperature, pressure and time. It is understood that analysis of only one sample per hydrolyzation condition does not allow for statistical conclusions regarding hydrolyzation method on ruminal DM degradation, but does provide an initial perspective on the subject; (see Table 22 for DM degradation results for each sample and its hydrolyzation conditions). There were some intriguing differences between feather meal with and without blood and between the pre- or post- hydrolyzation addition of blood.

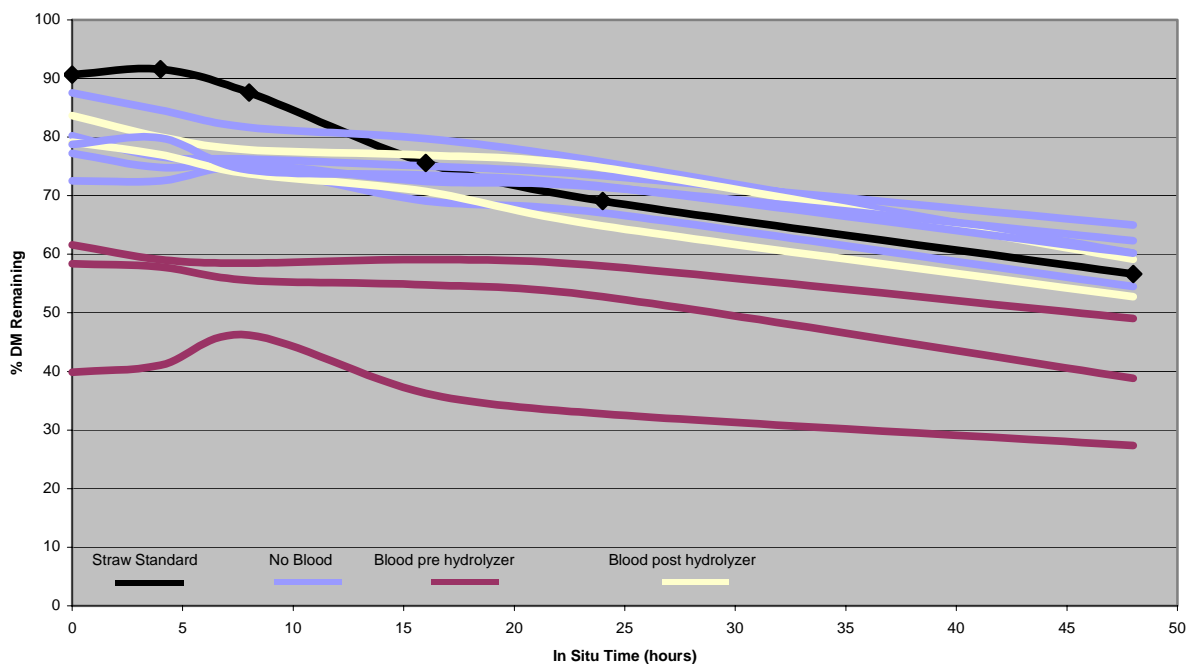


Figure 1. *In situ* DM degradation of selected feather meal samples.

Table 22. *In situ* DM degradation as affected by processing.

Lab ID	Temperature (°F)	Pressure (psi)	Time (minutes)	% blood	% degraded
1439	292	45	35	0	31
1448	190	40	30	0	28
1454	292	45	35	0	27
1445	270	60	5	0	25
1444	325	75	---	0	20
1442	300	45	30	38	45
1449	275	20	120	25	41
1453	300	67	12	12	29
1446	298	50	30	3	23
1486	270	30	60	10	64

The five feather meal samples without blood showed similar *in situ* degradation curves over the 48-hour incubation period. All samples had rather flat and slow DM degradation. Samples of feather meal with blood showed a greater spread in digestibility, or possibly washout from the *in situ* bags at 0 hour of rumen incubation. The 0 hour incubation was a 15 minute incubation *in situ* in the rumen and immediate washing with cold water. Feather meal with blood added post hydrolyzation showed similar DM loss/degradation as the feather meal without blood of about 20%. Feather with blood added pre-hydrolyzation resulted in significant loss/washout of DM, nearly 40-60% of the sample DM was lost. Subsequent DM degradation was similar between feather with blood added post hydrolyzation and feather without blood as noted by the slopes of the degradation curves. Though a limited sample set, it appears that hydrolyzation of blood results in either a greater rate of ruminal protein degradation or possible solubilization from feather meal into the rumen fluid liquid phase. The degradation of feather with blood added after hydrolyzation was similar to feather with no blood at all.

Whether this difference is of nutritional significance is yet to be determined. The greater loss of DM at the 0 hour of rumen incubation could indicate either rapid rumen solubilization or more rapid outflow to the lower gut in the liquid phase or simply more rapid microbial degradation in the rumen. The question remains as to the ruminal out flow rate of feather meal particles, regardless of blood addition or time of hydrolyzation, and its subsequent digestibility in the lower gut. The inclusion of feather meal in ruminant diets is specifically to deliver amino acids to the lower gut for direct uptake. Digestibility of this protein source is critical for users to obtain value from feather meal.

The rate of rumen degradation of DM, and presumably CP, has been crudely estimated in this small *in situ* trial. By subtracting the 48-hour DM residue from the 0 hour residue value results in a loss of about 20% of the sample over the incubation period. This results in a rate of ruminal degradation of about 0.4%. The range for the 10 samples analyzed was about 0.2-0.6% DM degradation per hour. Figure 2 depicts the rumen degradable protein fractions of interest. In CPM 3.0 terminology, the 0 hour loss of CP is fraction A, soluble protein. The whole tract indigestible protein is fraction C, determined as the ADICP. The residue remaining at 48 hours was considered to be ruminally indigestible protein and is therefore greater than the ADICP fraction as determined by Dairy One. For display purposes in Figure 2, this residue is also labeled protein fraction C, rumen undigested protein. Note ADICP refers to protein that is indigestible through the entire gastro-intestinal tract. The remaining protein fraction is then partitioned by rate of ruminal degradation, decreasing from fraction B1 to B2 to B3. Fraction B3 is considered rumen undegraded protein that is digestible in the lower gut. In the case of this dataset, there does not appear to be any difference in rate of degradation as noted by the constant slope indicating straight line rate of rumen degradation of feather meal DM and inferred CP. Previous versions of CPM had estimated values of protein degradation of 3% per hour. This limited trial indicated that the actual rate may be less than 1% per hour. Until more extensive research can be conducted to accurately determine the ruminal rate of protein degradation a value of 1% per hour was used for the protein B3 degradation rate in CPM 3.0.

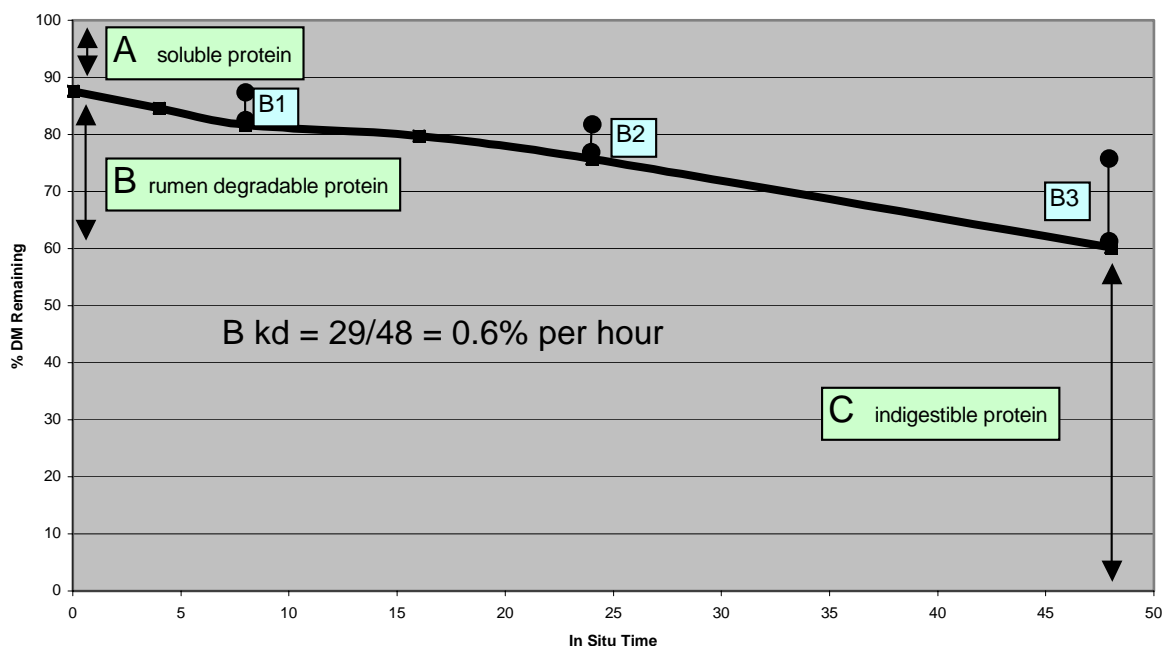


Figure 2. Explanation of protein fractions and determination of ruminal protein degradation rate as required for CPM 3.0.

One of the primary objectives for conducting this project was to more clearly and thoroughly define the nutrient profile of feather meal products for use in the ruminant and non-ruminant feed industries. Reviewing the NRC 2001 feed dictionaries and the Feedstuffs 2005 ingredient analysis table, two sources frequently used for “book value” analyses, showed a lack of complete nutritional profile and in many cases nutritional values derived from limited sample numbers. This project analyzed over 225 samples for DM, CP, fat and ash. Composites were made from those samples to generate 18 weekly samples of feather meal without blood across 6 processing plants and 27 weekly composites of feather meal with blood across 9 processing plants. The break down of feather meal into blood and no blood seems to be the easiest means of differentiating product. Of course there are some processing plants that include greater amounts of viscera. In fact one plant in this project had to be omitted from the dataset because of its unique product. In cases such as this, it is imperative that samples be analyzed for a thorough nutritional profile. Considering that most feather meal can be categorized as with or without blood it seems reasonable to use that as the differentiation with the understanding that there are other feather meal products being produced by individual processing plants with quite unique nutritional profiles. The NRC 2001 distinguishes between hydrolyzed feather meal with and without viscera, where as Feedstuffs has only a single feather meal entry. The nutritional analyses of the current sample set to be used in CPM 3.0 Feed Dictionary and the most recent book values in the NRC 2001 and Feedstuffs 2005 issue are presented in Table 23. The most obvious difference in the profiles is the complete set of analyses including protein fractions as defined in CPM 3.0; soluble protein, ADCIP and NDICP, the amino acid profile of the BIR estimating rumen undegradable protein and the fatty acid profile. Interestingly the amino acid profile of the BIR for the CPM 3.0 database is very similar to the CP based amino acid profile found in the NRC 2001. Both of which are quite different from the values found in the

Feedstuffs dictionary. In many cases the CPM 3.0 and NRC 2001 amino acid levels are nearly twice those of the Feedstuffs values for CP. Histidine shows the greatest difference with the Feedstuffs value being only 38% of the CPM 3.0 value. Considering the use of feather meal product as an important source of amino acids in both ruminant and non-ruminant feeds, the accuracy of the amino acid profiles is critical. The Feedstuffs dictionary also includes digestibility coefficients for individual amino acids, though it is unclear if these values are still current. It would be advantageous to have a better understanding of the digestibility of feather meal product protein and amino acids both in the rumen and in the small intestine. This data would be beneficial to both the ruminant and non-ruminant feed industry.

Table 23. Comparison of current analyses with previous reference values, CNCPS profile.

Item	CPM 3.0 Feather Meal No blood	CPM 3.0 Feather Meal Added blood	Feedstuffs 2005 edition (2004) Feather Meal, poultry	NRC 2001 Feathers Hydrolyzed meal	NRC 2001 Feathers hydrolyzed meal w/some viscera
DM, %	93.3	93.5	93.0	93.3	91.5
CP, %	87.8	87.7	85.0	92.0	85.0
EE, %	10.0	9.46	2.5	4.60	8.80
Ash, %	1.9	2.6	3.9	3.5	5.5
Density, lb/ft ³					
SP, %	7.4	10.0			
NDICP, % CP	49.9	51.2			
ADICP, % CP	26.5	18.9			
Ca, %	0.54	0.51	0.20	0.33	1.36
P, %	0.34	0.39	0.70	0.50	0.77
Mg, %	0.03	0.04	0.20	0.22	0.06
Cl ion, %	0.17	0.33	0.28	0.26	0.47
K, %	0.13	0.21	0.30	0.33	0.24
Na, %	0.11	0.24	0.70	0.34	0.27
S, %	1.78	1.71	1.40	1.39	1.75
Cu, ppm	11	11	7	10	12
Fe, ppm	239	607	70	76	625
Mn, ppm	7	7	9	10	12
Zn, ppm	87	83	55	111	100
ADICP, %	23.2	16.4			
NDICP, %	44.0	44.7			
NSC, %	1.9	2.0			
TDN, %	82.4	81.1	63		
NEL, Mcal/lb	0.92	0.90			
NEM, Mcal/lb	0.98	0.96			
NEG, Mcal/lb	0.68	0.66			
Available protein, %	64.6	71.3			
Adjusted CP, %	65.6	72.3			
Starch, %	0.7	0.6			
Sugar, %	1.2	1.4			
Mo, ppm	0.5	0.6			

Table 24. Comparison of current analyses with previous reference values, amino acid profile.

Item	CPM 3.0	CPM 3.0	Feedstuffs 2005	NRC 2001	NRC 2001
	Feather Meal No blood	Feather Meal Added blood	edition (2004) Feather Meal, poultry	Feathers Hydrolyzed meal	Feathers hydrolyzed meal w/some viscera
Dry matter, %	94.7	95.1			
Crude protein, %	86.0	85.4			
Insoluble CP, %	81.0	78.2			
Insoluble CP, % CP	94.2	91.7			
Soluble CP, % CP	5.8	8.3			
Taurine, % TAA	0.01	0.02			
Hydroxyproline, % TAA	0.04	0.05			
Asp, % TAA	6.49	6.81			
Thr, % TAA	4.58	4.60	2.80	4.73	4.70
Ser, % TAA	10.29	9.17			
Glu, % TAA	10.03	9.99			
Pro, % TAA	10.01	9.34			
Lanthionine, % TAA	1.53	1.49			
Gly, % TAA	7.48	7.01			
Ala, % TAA	4.38	4.70			
Cys, % TAA	5.47	5.15	3.00	5.09	4.34
Val, % TAA	7.54	7.56	4.55	7.52	6.76
Met, % TAA	0.70	0.77	0.55	0.75	0.84
Ile, % TAA	4.80	4.79	2.66	4.85	4.34
Leu, % TAA	8.21	8.54	7.80	8.51	8.44
Try, % TAA	2.81	2.91			
Phe, % TAA	4.91	5.10	2.66	4.93	4.83
Hydroxylysine, % TAA	<0.01	<0.01			
His, % TAA	0.74	1.28	0.28	1.15	1.33
Ornithine, % TAA	0.43	0.43			
Lys, % TAA	2.12	2.90	1.05	2.57	2.90
Arg, % TAA	6.88	6.73	3.92	6.93	6.27
Trp, % TAA	0.57	0.66	0.40	0.73	0.73

The number of processing plants and samples collected and analyzed for this project provide a significant national database for feather meal with and without blood inclusion. Preliminary review and presentation of these analyses differentiated between pre- and post hydrolyzation blood inclusion. Statistical review indicated that based on nutrient composition there was little difference between pre and post hydrolyzation addition of blood to feather meal. Though in terms

of rumen degradation there may in fact be a significant effect on protein degradation based on the time of blood inclusion. The topic of processing method and its effects on ruminal and post ruminal protein degradation characteristics needs further investigation.

The level of blood inclusion reported on the survey forms was somewhat confusing from our non-industry perspective. Recent discussions with industry personnel, including plant supervisors indicated that the range of blood inclusion level of 3-30% was unrealistic. It was proposed that the response of 3% was likely to mean 3 minutes of pump time that blood was being added to the product rather than 3% of the product by any measure of weight or volume. Most likely, plants using blood had similar inclusion levels. Though this is highly subject to the pumping capacity and length of time blood is pumped into the product for each plant. Consistency within each plant as to the amount of blood added to the feather meal needs to be considered, regarding the daily and weekly product nutrient variation observed in this study. For some plants a lack of consistent blood inclusion may be a cause for some of the within plant variation noted in tables 1-16. As an industry, the between plant variation of blood inclusion level may need to be considered with regards to the end users perception of product consistency. If feather meal buyers purchase product from various suppliers without understanding the inherent variation between plants, they may be disillusioned as to its usefulness. Though, if educated about the differences in processing techniques and resulting nutritional profile of the feather meal produced by each plant, users can be assured of product quality and usage implications. Understanding that the inclusion of blood significantly alters the nutritional profile concerning protein fractions and amino acids and to what extent, should allow nutritionists to have great confidence in using feather meal.

CONCLUSION

Resulting from this project is a complete and thorough nutritional profile of feather meal and feather meal with blood. Samples were collected from a majority of the feather meal processors in the U.S. and these analyses should adequately represent quality of product for the entire industry. Though as an industry and as individual producers and marketers of feather meal it may be beneficial to continue to monitor nutritional quality beyond the basics of DM, CP, fat and ash. The advent of precision feeding dictates the need for specific protein, amino acid and micronutrient analyses and digestibilities. Continued monitoring and research of feather meal nutrient composition will be beneficial. With greater understanding of how processing affects nutritional properties, it may be possible to tailor the nutritional properties of feather meal to meet specific nutritional needs of various species.

This project has also provided initial data regarding variation of nutrient composition within and between processing plants. Individual processors and the industry as a whole can use this information to examine their production parameters regarding quality control measures that affect the nutritional value of their product. A more consistent feather meal product across the industry could enhance total market usage.

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Abbreviations

ADF: acid detergent fiber
ADICP: acid detergent insoluble crude protein
Ala: alanine
aNDF: apparent NDF
AOAC: Association of Analytical Communities
Arg: arginine
Asp: aspartate
BIR: buffer insoluble residue
Ca: calcium
Cl: chloride
CNCPS: Cornell Net Carbohydrate and Protein System
CP: crude protein
Cu: copper
Cys: cysteine
DE: digestible energy
DM: dry matter
EE: ether extract, crude fat
FA: fatty acid
Fe: iron
ft: foot
g: gram
Gly: glycine
Glu: glutamic acid
His: histidine
Ile: isoleucine
K: potassium
kg: kilogram
lb: pound
Leu: leucine
Lys: lysine
ME: metabolizable energy
Met: methionine
Mg: magnesium
mg: milligram
ml: milliliter
Mn: manganese
Mo: molybdenum
N: nitrogen
Na: sodium
NDF: neutral detergent fiber
NDICP: neutral detergent insoluble crude protein
Neg: net energy growth
Nel: net energy lactation
Nem: net energy maintenance

NFC: non-fiber carbohydrate
NRC: National Research Council
NSC: non-structural carbohydrate; sugar and starch
P: phosphorus
Phe: phenylalanine
Pro: proline
RFPL: Rumen Fermentation Profiling Lab
S: sulfur
SAS: Stastical Analysis System
Ser: serine
SP: soluble protein in borate-phosphate buffer. Estimation of rumen soluble protein
TAA: total amino acids
TDN: total digestible nutrient
TFA: total fatty acid
Thr: threonine
Trp: tryptophan
Tyr: tyrosine
Val: valine
Zn: zinc

Appendix A. Sample submission form sent to plants.



1530 Cooledge Road, Tucker, GA 30084-7303
770 493-9401 • Fax 770 493-9257
www.poultryegg.org

ANALYSIS OF NUTRIENT COMPOSITION OF FEATHER MEAL AND FEATHER MEAL WITH BLOOD

PPFC Research Project #R54

Poultry Protein & Fat Council Feathermeal Project Sample Submission Form

Company Name: _____ **Miner Lab ID:** _____
Plant Location: _____
Plant Address: _____
Contact Person: _____
Phone Number: _____
Fax Number: _____
Email: _____

Product: Feathermeal (no blood added) Feathermeal (Blood added before hydrolyzer) Feathermeal (Blood added after hydrolyzer)

Collect a representative 1/2-pound sample of each day's production for five consecutive days. Refrigerate daily samples in zip lock bags. Note sampling method - shift composite, single grab, daily composite, or other (please describe). Repeat sampling for three consecutive weeks, send each week's samples (5 days) to Miner Inst. upon completion of the week.

Week _____
Collection Dates: Day 1 _____ Sampling method: _____
 Day 2 _____ Sampling method: _____
 Day 3 _____ Sampling method: _____
 Day 4 _____ Sampling method: _____
 Day 5 _____ Sampling method: _____

Processing Information:
 Hydrolyzation time: _____
 Hydrolyzer temperature: _____
 Hydrolysis pressure: _____
 % blood: _____
 Batch or continuous: _____
 Other comments: _____

Ship via UPS, Fed Ex or Priority Mail to:

Miner Institute
Attn: Forage Lab
586 Ridge Road
Chazy, NY 12921

Contact Info:
Kurt Cotanch
cotanch@whrminer.com
(518) 846-7121 x 123

Appendix B. Amino Acids feather meal with and without blood as percent of total amino acids recovered in original sample DM basis.

	No Blood Average	No Blood Standard Deviation	Blood Average	Blood Standard Deviation
%DM*	95.13	2.48	95.10	2.16
%Crude Protein	85.74	2.46	85.53	2.48
Taurine	0.04	0.02	0.05	0.03
Hydroxyproline	0.10	0.05	0.12	0.10
Aspartic Acid	6.64	0.09	6.90	0.10
Threonine	4.55	0.06	4.58	0.08
Serine	10.05	0.86	9.44	0.54
Glutamic Acid	10.48	0.23	10.46	0.30
Proline	9.34	0.39	8.95	0.41
Lanthionine	1.19	0.55	1.04	0.48
Glycine	7.64	0.21	7.35	0.23
Alanine	4.57	0.19	4.88	0.16
Cysteine	5.41	0.54	4.94	0.47
Valine	7.56	0.26	7.51	0.20
Methionine	0.72	0.05	0.78	0.05
Isoleucine	4.77	0.15	4.71	0.09
Leucine	8.18	0.19	8.44	0.18
Tyrosine	2.90	0.12	2.92	0.12
Phenylalanine	4.86	0.11	4.99	0.16
Hydroxylysine	0.00	0.00	0.00	0.00
Histidine	0.82	0.18	1.26	0.17
Ornithine	0.49	0.23	0.45	0.14
Lysine	2.29	0.26	2.90	0.25
Arginine	6.87	0.13	6.73	0.09
Tryptophan	0.53	0.11	0.59	0.09