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DEPARTMENT OF ANIMAL SCIENCES

SEPTEMBER 15, 2008

Dr. Sergio Nates
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Fats and Proteins Research Foundation, Inc.
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Dear Dr. Nates:

Project 05 A-7 Purdue Adeola
Re: Metabolizable Energy Value of Meat and Bone Meal - II
Final Report (09-15-2008)

I have attached to this letter an eight-paged final report. Animal work is completed on all three groups of meat and bone meal samples received. All analyses of diets, fecal and urine samples are complete and the summary of the results are presented in different tables. The concluding part of the work is the use of NIRS to predict AME and AMEn of the samples. This part of the work is not yet done, and further explanation is given in the summary section of the report. I plan to send this data to you as soon as it is available.

Thank you for the opportunity to work on the project.

Have a pleasant day,

Adeola

Layi Adeola, Ph.D.
Professor of Animal Sciences

FINAL REPORT **Date:** September 15, 2008

Submitted to: **Fats and Protein Research Foundation, Inc.**
801 N. Fairfax Street, Suite 205, Alexandria, VA 22314

Title: Metabolizable Energy Value of Meat and Bone Meal - II

By: Layi Adeola

University/Location: Purdue University, West Lafayette

Project Starting Date: September 1, 2005 **Completion Date:** March 31, 2008

Objectives:

1. Determine the metabolizable energy (ME) contents of a variety of samples of meat and bone meal for pigs.

2. Assess the variation in metabolizable energy contents of meat and bone meal and develop robust regression equations that relate the variation to chemical composition.

3. Investigate the use of near-infrared reflectance spectroscopy (NIR) in predicting the ME content of MBM for pigs. This aspect of the objective will use the 12 MBM samples from phase I and the 21 MBM samples from phase II of the MBM ME project.

Summary of Work to Date

Twenty-one samples of meat and bone meal (porcine and bovine origins) were selected, analyzed for proximate composition, and used in experiments to determine the energy value for pigs.. The samples selected represented a narrower range in chemical composition than used in phase I of the MBM ME project.

Given that ME values are extremely difficult to determine directly using MBM as the sole source of dietary energy, each of the 21 MBM samples is used in test diets formulated by replacing the same proportion of corn and soybean meal (SBM) and all of limestone and dicalcium phosphate of the standard diet with 100 g meat and bone meal sample/kg (Table 1). Corn and SBM are adjusted to constant ratio (745:255 for the standard diet and 745:255 for the test diet containing 100 g MBM/kg) in the substitutions. Because all the energy in the standard diet is derived from corn and SBM, this constant ratio is key for algebraic equations (described below) used in the indirect method of ME determination to derive the metabolizable energy (ME) content (in kcal/kg) of MBM. The same batch of corn, SBM, dicalcium phosphate and limestone are used for formulating all diets, the only source of variation is each of the 21 MBM samples.

The 21 MBM samples were shipped to Purdue University in 3 groups of 7 MBM samples per group. For each group of 7 MBM samples, 8 diets consisting of 1 standard diet (SD) and 7 test diets (TD) were fed to 72 Yorkshire-Landrace barrows in the weight range of 30 to 35 kg giving 9 barrows per diet. The SD and TD were fed to barrows in a metabolism assay that employed a 5-d adjustment followed by a 5-d period of total but separate collection of feces and urine. Pigs were housed in stainless-steel metabolism crates that allow separate collection of feces and urine using protocols described by Adeola and Bajjalieh, (1997). Details of this procedure are in the last project funded by FPRF (phase I of the MBM ME project).

The chemical analyses of the 3 groups of 7 MBM samples are presented Tables 1 to 3. Animal work is completed on all three groups of meat and bone meal samples received. Analyses of fecal and urine samples for the all the groups have been completed. In line with what was done during Phase I of the meat and bone meal project, meat and bone meal samples were sent to the Agricultural Experiment Station Chemical Lab at the University of Missouri for **proximate and amino acid composition analyses and the results are presented in Tables 4 and 5, respectively**.

The data of energy contents (DE, AME and AMEn) of the 21 MBM samples are presented in Table 6. As expected, the energy values decreased from GE to AMEn. There were no great variations in the AME and AMEn values of the 21 MBM samples, although samples 101 ands 117 had the highest AME and AMEn whereas sample 106 and 109 had the lowest AME and AMEn of the 21 samples. This does not appear to be correlated to any specific variation in the chemical composition of the MBM samples.

Table 7 presents the Pearson correlation coefficients of the chemical compositions of the MBM samples. Of all the chemical components, AME and AMEn were most highly and positively correlated with fat content and had the lowest correlation with GE. Apparent ME and AMEn were also negatively correlated with CP, ash, phosphorus and calcium and very highly correlated with DE. Overall though, GE had much higher correlation with any of the chemical components than either AME or AMEn.

Multiple regression analysis was used to generate prediction equations for AME and AMEn based on the chemical compositions of the MBM samples. **The parameters and coefficients for each factor are presented in Table 8.** The best model for predicting both AME and AMEn of MBM for swine incorporated 4 variables namely GE, phosphorus, protein and ash. The 4-variable prediction equations for AME is: AME = 13, 587 – (1.25 × GE, kcal/kg) – (3.51 × Protein, g/kg) + (30.4 × P, g/kg) – (16.4 × Ash, g/kg) and for AMEn, the equation is: AMEn = 13, 547 – (1.25 × GE, kcal/kg) – (3.59 × Protein, g/kg) + (31.0 × P, g/kg) – (16.5 × Ash, g/kg).

The remaining part of the study is to use NIRS to predict the AME and AMEn of the MBM samples. We have run to considerable difficulty with this aspect of the study. For one thing, the laboratory that is supposed to do the work is located in Europe and because of the difficulty of sending materials containing animal tissues to Europe made it ill-advised to send the samples there for analyses. When we realized this difficulty, the laboratory in Europe linked us with a branch of their laboratory here in Ohio. However, just as we were planning to take the samples to Iowa for analysis, we received news that the NIR machine broke and they have not been able successful at fixing the machine even though they have tried to do so several times. Right now, the machine is working rather sporadically and although we are planning to take the samples to Ohio for analysis, there is no indication that the machine will work at this time. We plan to send this data (on NIRS) to you as soon as it is available.

Table 1: Chemical analysis (DM basis) of group 1 meat and bone meal samples

Sample Number	DM, %	GE, kcal/g	CP, %*	Ether extract, %	Phosphorus, %	Calcium, %	Ash, %
101	98.4	4.27	55.1	14.1	5.6	8.7	27.5
102	96.1	4.66	63.8	10.8	3.8	5.7	21.6
103	97.5	4.17	56.0	11.1	4.9	8.6	27.3
104	95.4	4.61	61.6	14.4	4.3	6.9	21.5
105	95.5	4.27	59.2	10.8	4.6	8.0	26.2
106	97.6	3.90	47.8	13.6	5.8	9.3	32.8
107	98.9	3.97	49.7	10.7	5.0	7.9	30.6

* N x 6.25
Brief description of MBM samples contained on the labels:
101 - Contains ruminant feed
103 – All pork
104 - Mixture: beef 75%, pork 10%, chicken 10%, fish 5%. Raw material approx 70% retail and 30 % slaughter house
105 – High essential amino acid, 57% meat meal

Table 2: Chemical analysis (DM basis) of group 2 meat and bone meal samples

Sample Number	DM,%	GE, kcal/g	CP, %*	Ether extract, %	Phosphorus, %	Calcium, %	Ash, %
115	98.9	5.08	53.5	13.2	1.9	2.5	13.8
116	98.9	5.11	49.2	13.2	2.0	2.6	14.7
117	99.0	5.19	54.9	14.0	2.1	2.6	14.2
118	99.8	4.64	58.4	9.9	4.1	7.3	25.3
119	99.3	4.63	60.3	10.5	3.7	5.7	23.1
120	99.8	4.25	59.1	10.3	2.6	4.3	22.1
121	99.8	4.70	60.6	11.6	2.9	5.4	21.5

* N x 6.25
Brief description of MBM samples:
115-117 – No description available, none was supplied by suppliers (Valley Protein, Inc. VA)
118-121 – Mixture of beef, pork and poultry products.

Table 3: Chemical analysis (DM basis) of group 3 meat and bone meal samples

Sample Number	DM,%	GE, kcal/g	CP, %*	Ether extract, %	Phosphorus, %	Calcium, %	Ash, %
108	98.2	4.72	62.9	9.4	3.9	6.5	22.2
109	98.5	4.77	64.6	10.0	3.5	7.0	20.3
110	98.7	4.76	62.4	9.6	3.6	7.0	21.0
111	98.9	4.73	63.7	10.5	4.0	7.4	20.9
112	98.9	4.72	62.4	10.4	4.0	7.2	22.9
113	99.2	4.79	61.4	10.6	4.1	8.0	23.0
114	99.1	4.70	61.8	11.3	3.8	7.4	22.0

* N x 6.25
Brief description of MBM samples:
108-114 – No description available, none was supplied by suppliers

Table 4: Chemical analysis (DM basis) of all the meat and bone meal samples (21) as analyzed by Missouri Experimental Station Chemical Laboratory

Sample Number	DM,%	CP, %*	Ether extract, %	Phosphorus, %	Calcium, %
101	96.0	54.9	10.5	4.7	9.5
102	93.9	64.1	10.1	3.8	7.1
103	95.2	57.1	10.5	5.1	10.3
104	94.6	60.1	11.9	3.7	8.0
105	93.9	61.2	9.2	4.7	9.3
106	95.6	49.1	12.0	5.6	11.6
107	96.5	51.4	12.1	5.1	10.7
108	96.2	63.1	10.1	3.7	6.7
109	96.5	62.9	10.7	3.2	6.6
110	96.4	63.2	10.2	3.6	6.5
111	96.6	55.4	10.9	3.8	7.7
112	96.3	62.6	11.2	3.9	7.3
113	96.7	62.1	11.1	3.9	7.3
114	96.7	61.9	11.5	3.8	7.8
115	94.2	57.0	13.6	2.3	3.8
116	94.4	56.9	13.5	2.4	4.1
117	94.5	57.3	14.1	2.3	3.7
118	97.1	57.1	11.1	4.4	9.7
119	95.3	62.6	10.5	4.2	7.9
120	96.9	56.7	10.6	3.0	8.7
121	96.7	59.4	11.6	3.5	7.0

* N x 6.25

Table 5: Amino acid analysis (%, as is basis) of all the meat and bone meal samples (21) as analyzed by Missouri Experimental Station Chemical Laboratory

Sample number/ Amino acids	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121
Essential amino acids																					
Arginine	3.44	3.80	3.71	3.78	3.76	3.20	3.35	3.61	3.66	3.63	3.61	3.77	3.72	3.67	3.24	3.21	3.26	3.66	3.96	3.49	3.67
Histidine	1.02	1.52	0.95	1.28	1.14	0.78	0.82	1.42	1.44	1.45	1.34	1.39	1.39	1.35	1.29	1.23	1.29	1.10	1.06	1.25	1.37
Isoleucine	1.56	2.12	1.49	2.12	1.74	1.26	1.31	2.08	2.11	2.02	2.01	2.01	2.00	1.99	2.00	1.91	2.01	1.69	1.92	1.90	2.01
Leucine	3.21	4.13	3.17	4.01	3.49	2.69	2.84	3.96	3.96	3.87	3.80	3.83	3.81	3.73	3.73	3.58	3.72	3.42	3.79	3.65	3.87
Lysine	2.96	3.81	2.78	3.70	3.13	2.36	2.34	3.66	3.72	3.73	3.57	3.68	3.67	3.62	3.00	2.90	3.02	2.98	2.85	3.23	3.46
Methionine	0.70	1.02	0.73	1.07	0.79	0.61	0.59	0.96	0.96	0.94	0.95	0.94	0.93	0.93	0.84	0.83	0.86	0.82	0.78	0.94	0.95
Phenylalanine	1.77	2.22	1.72	2.16	1.93	1.50	1.57	2.14	2.12	2.10	2.05	2.06	2.06	2.02	2.05	1.97	2.04	1.89	2.12	2.02	2.10
Threonine	1.62	1.95	1.66	2.07	1.78	1.38	1.38	2.10	2.04	2.03	1.98	1.96	1.95	1.86	1.87	1.79	1.82	1.68	1.91	1.81	1.94
Tryptophan	0.40	0.47	0.35	0.50	0.42	0.32	0.29	0.46	0.47	0.47	0.40	0.44	0.42	0.43	0.36	0.36	0.43	0.35	0.33	0.45	0.47
Valine	2.31	2.94	2.25	2.79	2.57	1.90	2.04	2.69	2.74	2.59	2.63	2.64	2.63	2.62	2.60	2.51	2.61	2.42	2.89	2.61	2.71
Non essential amino acids																					
Alanine	3.77	4.23	3.71	3.91	4.02	3.41	3.71	4.01	4.01	4.06	4.07	4.14	4.12	4.07	3.42	3.38	3.42	4.04	4.13	3.66	3.94
Aspartic Acid	3.83	4.66	3.82	4.65	4.11	3.29	3.41	4.76	4.66	4.62	4.62	4.54	4.51	4.45	4.20	4.10	4.21	4.06	4.22	4.24	4.46
Cysteine	0.45	0.46	0.65	0.58	0.62	0.46	0.37	0.44	0.54	0.50	0.43	0.49	0.49	0.46	0.60	0.61	0.63	0.42	0.80	0.57	0.52
Glutamic Acid	6.19	7.55	6.49	7.27	6.72	5.46	5.72	7.39	7.42	7.64	7.23	7.24	7.22	7.14	7.18	6.87	7.01	6.70	6.89	6.75	7.19
Glycine	6.45	6.01	6.76	5.74	6.85	6.39	6.93	5.85	5.74	5.96	6.21	6.30	6.23	6.26	4.66	4.81	4.72	6.78	7.03	5.43	5.77
Hydroxylysine	0.29	0.24	0.26	0.24	0.29	0.27	0.30	0.23	0.25	0.24	0.26	0.27	0.26	0.27	0.18	0.20	0.20	0.31	0.30	0.23	0.27
Hydroxyproline	2.52	1.97	2.62	1.94	2.57	2.61	2.83	2.07	2.04	2.25	2.25	2.35	2.30	2.26	1.37	1.48	1.42	2.57	2.46	1.80	1.94
Lanthionine	0.01	0.01	0.31	0.01	0.22	0.07	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.21	0.34	0.01	0.01
Ornithine	0.07	0.08	0.05	0.04	0.07	0.04	0.04	0.09	0.08	0.06	0.10	0.08	0.08	0.08	0.06	0.08	0.09	0.08	0.10	0.06	0.07
Proline	4.06	3.99	4.34	3.81	4.42	3.75	4.09	3.93	3.82	4.29	4.48	4.05	3.99	4.00	3.08	3.36	3.30	4.00	4.71	3.62	3.61
Serine	1.77	1.81	1.99	2.06	2.08	1.63	1.56	2.05	1.99	2.04	1.94	1.92	1.91	1.77	1.85	1.76	1.74	1.72	2.42	1.76	1.87
Taurine	0.08	0.13	0.07	0.06	0.07	0.06	0.05	0.09	0.10	0.08	0.10	0.12	0.11	0.10	0.12	0.12	0.13	0.09	0.08	0.12	0.10
Tyrosine	1.24	1.52	1.20	1.56	1.21	0.97	0.99	1.46	1.47	1.45	1.39	1.42	1.39	1.35	1.40	1.34	1.38	1.31	1.41	1.33	1.41
Total	49.7	56.6	51.1	55.4	54.0	44.4	46.5	55.5	55.3	56.0	55.4	55.6	55.2	54.4	49.1	48.4	49.3	52.3	56.5	50.9	53.7

Table 6: Energy values and some chemical compositions of 21 meat and bone meal samples

Sample	GE, kcal/kg	DE, kcal/kg	AME, kcal/kg	AMEn, kcal/kg	Protein*, %	Ash#, %
101	4,269	3,658	3,384	3,283	54.9	27.5
102	4,657	3,389	3,080	2,963	64.1	21.6
103	4,167	3,967	3,762	3,661	57.1	27.3
104	4,605	4,252	3,842	3,733	60.1	21.5
105	4,270	3,185	2,840	2,729	61.2	26.2
106	3,895	2,669	2,611	2,512	49.1	32.8
107	3,968	3,241	3,101	3,001	51.4	30.6
108	4,722	3,387	3,001	2,889	63.1	21.7
109	4,769	2,792	2,613	2,510	62.9	22.2
110	4,761	3,125	2,714	2,600	63.2	22.7
111	4,734	3,576	3,210	3,102	55.4	24.1
112	4,720	3,534	3,267	3,170	62.6	22.5
113	4,789	2,704	2,320	2,212	62.1	24.2
114	4,702	3,367	2,988	2,881	61.9	23.1
115	5,077	3,670	3,160	3,053	57.0	13.8
116	5,106	3,863	3,581	3,479	56.9	14.7
117	5,193	4,234	3,911	3,806	57.3	14.2
118	4,640	3,033	2,804	2,694	57.1	25.3
119	4,627	3,385	2,991	2,875	62.6	23.1
120	4,247	3,468	3,031	2,922	56.7	22.0
121	4,697	3,696	3,346	3,237	59.4	21.5

* N x 6.25
#Analyzed at Purdue University
THE PROTEIN VALUES HERE ARE AS REPORTED BY MISSOURI

Table 7: Correlation of AME and AMEn of 21 meat and bone meal with their chemical compositions

	AME	AME_n	DE	GE	Protein	Phosphorus	Calcium	Fat	Ash
AME	-	0.99	0.92	0.15	-0.25	-0.20	-0.25	0.41	-0.29
AMEn			0.93	0.15	-0.26	-0.19	-0.24	0.42	-0.29
DE				0.34	-0.07	-0.38	-0.40	0.40	-0.48
GE					0.50	-0.86	-0.94	0.44	-0.95
Protein						-0.34	-0.42	-0.44	-0.42
Phosphorus							0.93	-0.49	0.91
Calcium								-0.50	0.98
Fat									-0.52
Ash									-

Table 8: Regression equations for predicting AME and AMEn of 21 meat and bone meal based on their chemical compositions

Variables in the model	Parameters estimates						
	Intercept	GE, kcal/kg	Protein, g/kg	Phosphorus, g/kg	Calcium, g/kg	Fat, g/kg	Ash, g/kg
Apparent metabolizable energy, kcal/kg							
1	1,530					13.3	
2	13,037	-1.54					-12.2
3	12,727	-1.14	-3.24				-10.7
4	13,587	-1.25	-3.51	30.4			-16.4
5	14,994	-1.20	-4.90	31.6		-5.49	-16.1
6	15,190	-1.22	-5.02	33.2	-2.60	-5.88	-16.8
Apparent nitrogen-corrected metabolizable energy, kcal/kg							
1	1,401					13.5	
2	6,451		-4.49				-3.72
3	12,670	-1.14	-3.31				-10.7
4	13,547	-1.25	-3.59	31.0			-16.5
5	14,870	-1.21	-4.90	32.2		-5.16	-17.5
6	15,071	-1.23	-5.02	33.8	-2.69	-5.56	-16.9