Tech Topics

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Meat and Bone Meal Usage in Modern Swine Diets

The protein-rich ingredients and energy dense fats produced by the rendering industry have been and, especially now, should be an integral part of profitable swine feeding programs. With the availability of a number of commercially synthesized nutrients, nutritionally adequate swine diets can be made without the use of animal by-product ingredients. However, the most cost-efficient modern feeding programs provide a number of animal protein and fat alternatives within the "best cost" models for swine rations for all phases of production.

Meat and bone meal (MBM) has traditionally been an excellent source of calcium, phosphorus, protein, and amino acids as well as other micronutrients. Modern production practices as well as changes in the feed ingredient markets and formulation technology all account

Table 1. Compositional Data for MBM Received Through the Fats and Proteins Research Foundation (FPRF)

Sample	DM	CPAIS	CPDM	Fat	Ash	Ca	P	THR	CYS	MET	LYS	TRY
MBM 1	96.86	57.20	59.05	13.56	26.85	6.70	3.09	2.02	0.53	0.93	3.24	0.40
MBM 2	97.38	47.50	48.78	24.10	35.99	10.24	4.36	1.28	0.41	0.53	1.93	0.19
MBM 3	95.91	59.08	61.60	24.37	20.93	6.09	2.70	1.99	0.60	0.85	3.09	0.37
MBM 4	95.64	55.21	57.73	15.95	29.59	8.57	3.80	1.83	0.55	0.89	2.90	0.27
MBM 5	98.02	55.06	56.16	17.06	26.15	6.93	3.57	2.10	0.59	1.04	3.04	0.35
MBM 6	97.52	55.76	57.17	16.62	26.93	7.19	2.56	2.06	0.67	0.91	3.16	0.36
MBM 7	95.17	46.29	48.64	17.27	32.13	8.72	4.11	1.49	0.48	0.61	2.31	0.17
MBM 8	96.01	55.26	57.56	15.41	30.15	8.90	4.06	1.92	0.54	0.93	3.01	0.37
MBM 9	94.40	47.13	49.92	16.05	30.07	7.51	4.86	1.69	0.45	0.81	2.65	0.32
MBM 10	97.72	53.02	54.25	13.51	29.97	8.90	4.25	1.76	0.53	0.75	2.64	0.26
MBM 11	98.40	57.05	57.97	16.48	25.01	6.53	3.31	2.12	0.45	0.98	3.21	0.31
MBM 12	94.75	57.17	60.37	16.33	23.18	6.78	3.35	1.95	0.59	0.88	3.23	0.33
MBM 13	94.73	57.04	60.21	15.35	25.09	8.01	3.96	1.84	0.51	0.79	3.00	0.33
MBM 14	96.28	48.02	49.87	15.45	28.47	7.91	3.51	1.54	0.53	0.55	2.35	0.26
MBM 15	93.19	55.04	59.06	19.87	23.44	7.16	3.52	1.82	0.79	0.75	2.65	0.25
MBM 16	96.29	45.88	47.65	19.63	23.39	6.50	3.25	1.66	0.53	0.61	2.49	0.25
MBM 17	95.19	53.39	56.08	15.84	27.26	7.54	3.57	2.01	0.56	0.88	3.34	0.40
MBM 18	94.43	48.90	51.79	18.47	27.95	7.12	3.68	1.95	0.41	0.78	2.80	0.36
MBM 19	97.32	47.15	48.44	10.99	37.57	11.80	5.57	1.38	0.41	0.57	2.18	0.23
MBM 20	No sample submitted											
MBM 21	93.03	47.90	51.48	17.90	30.03	8.42	4.17	1.51	0.41	0.64	2.37	0.27
MBM 22	96.59	56.00	57.97	14.68	22.87	6.52	3.34	2.10	0.65	0.88	3.19	0.36
MBM 23	95.53	52.24	54.68	13.21	29.08	8.19	4.00	1.63	0.51	0.68	2.65	0.28
MBM 24	95.83	56.14	58.58	15.61	21.75	6.02	3.08	1.99	0.50	0.88	3.22	0.42
MBM 25	95.35	51.32	53.82	25.03	28.83	8.94	4.09	1.77	0.42	0.81	2.85	0.32
MBM 26	97.05	55.89	57.59	12.62	27.88	8.18	3.77	1.96	0.51	0.89	3.21	0.33
MBM 27	94.91	47.48	50.03	18.24	28.54	9.74	4.72	1.41	0.34	0.60	2.35	0.27
MBM 28	96.53	55.43	57.42	18.56	19.32	5.26	3.06	1.91	0.56	0.80	3.19	0.34
MBM 29	97.62	49.58	50.79	16.99	31.62	10.01	4.98	1.53	0.42	0.64	2.49	0.28
MBM 30	96.04	58.52	60.93	15.97	20.65	6.36	3.37	2.06	0.84	0.84	2.90	0.32
Average	95.90	53.60	55.92	17.00	26.44	7.58	3.67	1.83	0.58	0.78	2.87	0.32
Std. Deviations	1.44	5.99	6.52	3.26	6.20	1.96	0.89	0.032	0.033	0.14	1.49	0.08
Maximum	98.40	59.08	61.60	25.03	37.57	11.80	5.57	2.10	0.84	1.04	3.34	0.40
Minimum	93.03	45.88	47.65	10.99	19.32	5.26	2.56	1.28	0.34	0.53	1.93	0.17

American Oil Chemists' Society *Official Methods of Analyses (14th Edition)*. 1984. Association of Analytical Chemists, Washington, DC. University of Illinois, Department of Animal Sciences Laboratory, Urbana, IL.

DM=Dry Matter; CPAIS=Crude Protein in As IS basis; CPDM=Crude Protein in DM basis; Ca=Calcium; P=Phosphorus; THR=Threonine; CYS=Cystine; MET=Methionine; LYS=Lysine; TRY=Tryptophan for reasons that MBM be included in today's swine diets. As the North American pork industry continues its evolution and consolidation into a global marketplace, there will be a need to continue the priority on cost-effective feeding and production methods. Nutrition programs for swine will need to adapt to more alternative and by-product ingredients. As the marketplace for corn is diverted to ethanol production and soybeans to human food and energy sources, both animal and plant by-product sourced feed ingredients will become more important. The past reliance on corn-soy based swine rations due in part to the simplicity of on-farm blending of home raised or local corn, commodity soybean meal, and a convenience package of vitamins and minerals is no longer applicable to modern swine production. Central feed manufacturing practices that more effectively control quality while providing the benefits of storing and utilizing multiple ingredients for best cost computer formulations allow for modern production systems to maximize both performance and economy.

Though not always resulting in the most efficient or providing optimum performance, the simplicity of "mix-mill," "corn-soy," and "on-farm mixed" diets became the standard diets for the grow-finish and production herd during the 1970s and 1980s. Animal protein ingredients were essentially relegated to special use, commercial supplements, and pre-mix feed programs. As a result, the knowledge and familiarity with animal by-product ingredients for swine is limited for many nutritionists and veterinarians. This is especially evident for MBM. Though there are a number of animal protein ingredients that provide nutrient benefits in formulating swine diets, MBM is probably the most commonly used animal protein ingredient in swine rations. It is likewise supplied in the largest quantity. MBM by ingredient definition must contain a minimum of four percent phosphorus with a calcium level not to exceed 2.2 times the actual phosphorus level. Ingredients of lower phosphorus content must be labeled as meat meal (MM). This distinction in product description has created some confusion in development of databases, formulation specifications, and interpretation of the results of several published research reports. Many data sets have been taken from research that intentionally assembled products from a variety of sources and were designed to illustrate wide ranges of variability to meet specific research objectives. The restricted use protein products regulations[1] have also resulted in the segregation of porcine and ruminant raw materials into separate processing. The resultant products have different nutrient compositional values. In general, exclusive pork MBM contains higher protein and lysine levels but lower levels of phosphorus and calcium when compared to all ruminant or mixed species product. Please note that any feed ingredient containing restricted use protein products must be so labeled with appropriate warning statements.

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A database prepared by Bellaver et al. evaluated MBM samples selected to represent a variety of raw materials and processing conditions and illustrated that 100 percent beef-derived product yielded MBM with an average 50.6 percent protein and 32.2 percent ash, where as 100 percent pork-derived product yielded an average of 60.9 percent protein and 23.0 percent ash.[2] The compositional data, average digestibilities of protein, lysine, tryptophan, and methionine and the composition and processing conditions of the raw material are provided in Tables 1, 2, and 3 respectively. This document also contains prediction equations for crude protein, lysine, and methionine plus cystine for in vivo digestibility values. Scott et al. evaluated 13 commercially available exclusive porcine MBM products from both independent renderers and commercial packing plants that yielded concentrations of crude protein that ranged from 53.5 percent to 65.5 percent with an average of 59.5 percent protein.[3] All MBM and MM must be labeled with guaranteed protein as well as minimum phosphorus, minimum and maximum calcium, and minimum crude fat.

In today's marketplace, most suppliers of both MBM and MM can provide greater detail on mean value and specificity of nutrient content than obtained from the array of published compositional tables. With that said, a review of the most frequently referenced composition table, the National Academies' National Research Council (NRC) *Nutrient Requirements of Swine: 10th Revised Edition, 1998* is a very representative database.[4] It provides minimum values and a margin of safety for the descriptions of "rendered meat with bone" (referring to MBM) and "meat meal rendered," and is summarized for a number of nutrients in Table 4. There are several databases illustrating the general improvement in the product quality of MBM as attention to raw material and processing conditions have improved.[5] The 1988 NRC swine nutrition report stated lysine content of MBM at 2.89 percent; that value was lowered in the 1998 report to 2.6 percent. However, the database as summarized and presented in Table 1 reports an average of 2.87 percent, nearly identical to the 1988 published value. In comparing values of other feedstuffs, such as dehulled soybean meal, it is interesting to note that the protein composition has been lowered from 48.5 percent to 47.5 percent and its lysine content from 3.12 percent to 3.02 percent in these two publications. The stated lysine for dehulled soybean meal in the 1978 NRC edition is 3.18 percent. Thus nutrient profiles must be amended. This is advised as the interest and utilization of MBM as a swine feed ingredient continues to increase.

The currently stated metabolizable energy (ME) content in the 1998 NRC report is 2,225 kilocalories per kilogram (kcal/kg) for meat meal rendered with bone and 2,595 kcal/kg for MM rendered. Research is in progress to study the energy derived from MBM in modern grow-finish swine diets. Adeola and associates at Purdue University have evaluated six of 12 MBM samples derived from commercial sources selected to reflect variability in composition.[6] Twenty-four pigs with an average weight of 34 kg are randomly assigned to eight blocks of three pigs each to receive diets of either zero, five, or 10 percent MBM. Preliminary data on the six samples indicates ME of the MBM ranged from between 2,430 and 3,280 kcal/kg. These data will be presented at the July 2004 American Society of

Table 2. Average Digestibility for MBM Received Through the FPRF

Sample	Crude Protein	Lysine	Tryptophan	Methionine and Cystine
MBM 1	69.13	68.60	67.34	61.55
MBM 2	66.43	71.72	73.46	64.74
MBM 3	66.03	65.57	67.33	61.45
MBM 4	73.84	76.07	72.40	68.41
MBM 5	60.63	57.05	61.65	51.99
MBM 6	76.24	77.75	73.95	69.51
MBM 7	73.00	78.20	76.74	69.27
MBM 8	74.00	75.24	72.68	71.29
MBM 9	75.59	79.35	68.75	73.25
MBM 10	67.52	67.64	74.23	61.56
MBM 11	55.68	50.10	53.62	57.36
MBM 12	75.19	77.74	74.11	71.32
MBM 13	72.59	77.24	78.20	68.56
MBM 14	78.95	82.48	76.23	70.45
MBM 15	74.28	80.46	78.27	65.54
MBM 16	60.48	63.83	53.06	52.52
MBM 17	76.92	78.30	72.32	70.43
MBM 18	69.66	68.38	69.74	67.94
MBM 19	69.83	76.31	76.67	68.05
MBM 20	No sample submitted			
MBM 21	65.45	67.47	63.98	65.74
MBM 22	59.46	61.42	63.04	49.42
MBM 23	65.91	71.26	71.91	61.78
MBM 24	65.67	63.38	57.19	57.11
MBM 25	65.56	66.34	66.92	66.18
MBM 26	68.05	69.57	72.04	65.07
MBM 27	70.13	76.59	79.73	77.72
MBM 28	62.95	63.42	65.18	63.68
MBM 29	63.74	70.14	76.59	65.29
MBM 30	68.80	73.58	67.11	49.56
Average	68.68	70.87	69.70	64.30
Soybean Meal	80.02	83.14	79.06	77.26

Ileal T-cannula procedure as described by Easter and Tanksley (1993) and Bellaver (1989).

Animal Science meetings. The initial data supports the general theory that the ME of MBM is understated in a number of databases. The preliminary data indicates the ME increased as both the gross energy and fat contents of the different MBM samples increased, while decreasing with an increase in the MBM ash content.

MBM is not intended to serve as the exclusive protein source for swine rations. Its complimentary contributions at inclusion rates of up to 7.5 percent in grower diets and 10 percent in finishing diets supports excellent performance with economic benefits. The current price relationships with plant protein sources indicates substantial economic benefit for the inclusion of MBM. Some earlier research has reported reduced growth with the inclusion of MBM in pig diets. Speculation is that performance reduction was due to palatability and lowered feed intake.[7] More recently, Cromwell and Batterham et al. reported that the reduction in performance in pigs fed diets containing MBM was due to a deficiency in available tryptophan.[8][9] These researchers demonstrated that optimal growth performance could be achieved with the inclusion of 0.03 percent synthetic tryptophan for every 10 percent of MBM included in the diet.

The application of least (best) cost formulation and ideal protein modeling systems provide for a much greater opportunity to use and evaluate ingredients such as MBM and MM. The February 2004 *Render* contained additional reference information for utilizing animal by-product protein and fat in modern swine diets. In addition, references are provided on the microbiological

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Table 3. Composition and Processing Descriptions for MBM Received Through the FPRF

			Cooking		Drying		
Sample	Species	Components	Time	Temp.	Time	Temp	Grind
MBM 1	90% beef, 10% pork	-	-	-	2-1/2 hrs.	225°F	10 mesh
MBM 2	100% beef	75% offal, 25% bone		290-300°F	20 ton/hr. feed		8 mesh
MBM 3	100% pork	offal and bone	45 min.	130°C	-	No heat	1-2 mm
MBM 4	12% pork, 38% beef, 50% poultry	85% soft, 15% bone	4 hrs.	260°F	-	-	10 mesh
MBM 5	65% beef, 20% poultry 10% swine, 5% fish	90% soft, 10% bone	1 hr.	280-300°F	-	-	10 mesh
MBM 6	1/3 beef, 1/3 pork, 1/3 poultry	-	45 min.	260°F	-	-	8 mesh
MBM 7	60% beef, 40% pork	100% offal	20 min.	257°F	-	-	8 mesh
MBM 8	45% beef, 55% poultry	55% viscera, 45% bone	13-1/2 min.	155-230°F	-	-	8 mesh
MBM 9	100% beef	82% soft, 18% bone	Low temp.		45 min.	240°F	10 mesh
MBM 10	100% beef	82% soft, 18% bone	Low temp.		45 min.	240°F	10 mesh
MBM 11	28% beef, 33% pork, 38% poultry, 1% fish	42% viscera, 23% fat 22% bone, 10% muscle, 3% skin	-	260-290°F	-	-	-
MBM 12	No information obtained						
MBM 13	100% pork	No processing information obtained					
MBM 14	90% beef, 10% pork	49% offal, 22% fat 25% bone, 4% skin and trim	20 min.	250°F	-	-	10 mesh
MBM 15	14% beef, 77% pork, 9% poultry	70% offal, 15% bone, 15% fat	1-1/2 hrs.	240°F	-	-	-
MBM 16	70% beef, 30% pork	50% offal, 20% bone 25% shop fat, 5% restaurant grease bottoms	1 hr.	280°F	-	-	10 mesh
MBM 17	75% beef, 23% pork, 2% poultry	50% offal, 15% fat, 15% bone, 20% meat	30+ min.	270°F	290°F at press		1.7 mm
MBM 18	100% beef	40% offal, 45% fat, 15% bone	30+ min.	270°F	290°F at press		1.7 mm
MBM 19	100% beef	80% bone, fat, and offal, 20% tissue	30 min.	280°F	-	-	10 mesh
MBM 20	No sample submitted						
MBM 21	60% beef, 40% pork	40% offal, 60% fat trim and bone	65 min.	280°F	-	-	10 mesh
MBM 22	30% beef, 30% pork, 40% locker plant	-	3-1/2 hrs.	260°F	-	-	5/16 inch
MBM 23	40% beef, 60% pork	67% meat, 30% bone	90 min.	270°F	-	-	12 mesh
MBM 24	98% beef, 2% poultry	80% bone, fat, and offal	30 min.	280°F	-	-	10 mesh
MBM 25	15% beef, 20% pork, 65% poultry	65% offal, 27.5% bone, 7.5% fat	No time	260-280° F	-	-	10 mesh
MBM 26	75% beef, 25% pork and poultry	65% offal, 30% bone, 5% fat	No time	260-280°F	-	-	10 mesh
MBM 27	100% pork	-	2-1/2 hrs.	230°F	-	-	-
MBM 28	30% beef, 70% pork	-	30 min.	195°F	30 min.	212°F	10 mesh
MBM 29	98% beef, 2% pork	75% offal, 25% bone	-	290-300°F	-	-	10 mesh
MBM 30	10% beef, 90% pork	-	20 min.	262°F	-	-	10 mesh

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efficacy of rendering and biosecurity of rendered animal by-products. With the soybean supply at near record lows, prices at a 15-year high, and the expectation of higher soybean meal prices, the opportunity for swine nutritionists and veterinarians to re-acquaint themselves with these ingredients is upon us. It is also refreshing to note that a number of antinutritional compounds and contaminants such as trypsin inhibitors, goitrogenic compounds, gossypol, mycotoxin, glucosinolates, tannins, lectins, phytates, lathyrism, oxalates, nitrates, alkaloids, cyanogens, and oligosaccharides are not problematic in animal proteins. ❖

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Table 4. Nutrient Composition of Animal Proteins

Item	MBM
Crude Protein, %	51.5
Fat, %	10.9
Calcium, %	10.0
Phosphorus, %	5.0
ME, kcal/kg	2,225.0
Amino Acids	
Lysine, %	2.6
Methionine, %	0.7
Cystine, %	0.5
Threonine, %	1.6
Tryptophan, %	0.3
Valine, %	2.0
Isoleucine, %	1.3
Leucine, %	2.5
Phenylalanine, %	1.6
Tyrosine, %	1.1
Arginine, %	3.5
Histidine, %	0.9

National Research Council, 1998