FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

FRED D. BISPLINGHOFF, D.V.M.
Director Technical Services

7150 ESTERO BLVD. • APT. 906
FT. MYERS BEACH, FL 33931
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MEAT AND BONE MEAL IN SWINE DIETS

THE INITIAL AVAILABILITY OF ANIMAL PROTEINS CAME INCIDENTAL TO RENDERING ANIMAL FATS FOR EDIBLE, SOAP USE AND CANDLE MAKING. AT THE TURN OF THE CENTURY AS ANIMAL SLAUGHTER PLANTS GREW AND EXPANDED WITH THE GROWTH OF TRADING CENTERS SUCH AS THE CHICAGO STOCK YARDS, RENDERING ALSO EXPANDED, BECOMING A CONVENIENT DISPOSAL METHOD NOT ONLY FOR FATS, BUT FOR OFFAL AND BONES. THE USE OF ANIMAL FATS CONTINUED WITH THE SOLID, PROTEIN FRACTION BEING GENERALLY SPREAD ON LAND FOR WHAT FERTILIZER VALUE IT PROVIDED.

MEAT AND BONE MEAL HAS BEEN USED SUCCESSFULLY IN SWINE RATIONS FOR NEARLY A CENTURY. IT WAS THE FIRST SUPPLEMENT TO BE ADDED TO AN ALL-GRAIN RATION FOR SWINE AND IT DEMONSTRATED THE VALUE OF BALANCED RATIONS FOR THAT SPECIES. THE INITIAL USE OF ANIMAL PROTEINS AS A FEED INGREDIENT IS RELATED IN THE FOLLOWING STORY FROM THE NATIONAL PROVISIONER'S HISTORICAL, "MEAT FOR THE MULTITUDES" PUBLISHED JULY 4, 1981.

"ONE OF THE MOST SIGNIFICANT DEVELOPMENTS OF THE EARLY 1900s WAS THE DISCOVERY THAT DIGESTER TANKAGE -- PREVIOUSLY USED AS

A FERTILIZER MATERIAL -- WAS VALUABLE AS AN ANIMAL FEED CONSTITUENT. AT THAT TIME A MINIMUM OF NINE MONTHS WAS REQUIRED TO PRODUCE A HOG OF MARKETABLE WEIGHT AND FINISH. CORN ALONE WAS USED FOR FATTENING, AND FARMERS WERE ABLE TO RAISE ONLY ONE PIG CROP PER YEAR BECAUSE OF THE TIME NEEDED TO BRING THE ANIMAL TO MARKET WEIGHT.

IN 1901, PROFESSOR C. S. PLUMB OF PURDUE UNIVERSITY -- PERHAPS TAKING A HINT FROM EUROPEAN FEEDING PRACTICES -- ADDED A QUANTITY OF ANIMAL PROTEIN MATERIAL TO THE CORN RATION BEING FED TO HOGS AT PURDUE. THE PROTEIN SUPPLEMENT USED WAS TANKAGE. PLUMB'S EXPERIMENT INDUCED SUCH AN ACCELERATION OF GROWTH THAT HIS PIGS WERE READY FOR MARKET IN SEVEN MONTHS OR LESS. ABOUT THE SAME TIME OTHER EXPERIMENTERS WERE MIXING DRIED BLOOD WITH VARIOUS CEREALS TO PRODUCE BETTER FEEDING RATIONS. SWIFT & COMPANY TOOK PRIDE IN THE FACT THAT THE 1903 INTERNATIONAL CARLOT CHAMPION HOGS -- 52 ANIMALS AVERAGING 365 LBS. AND DRESSING OUT AT 84.01% -- HAD BEEN FED ON THE FIRM'S DIGESTER TANKAGE."

MEAT AND BONE MEAL PROVIDED NOT ONLY THE NECESSARY AMINO ACIDS TO BALANCE THOSE FOUND IN THE GRAIN BUT ALSO PROVIDED THE CALCIUM, PHOSPHORUS AND CERTAIN TRACE MINERALS (ZINC AND IRON) AND VITAMINS (B_{12}) REQUIRED BY THE PIG. THE DRAMATIC IMPROVEMENT IN GROWTH AND HEALTH OF THE PIGS THAT ACCOMPANIED THIS DEVELOPMENT ASSURED THE CONTINUED USE OF MEAT AND BONE MEAL IN SWINE RATIONS TO THE PRESENT DAY.

TABLE I LISTS THE CALCIUM, PHOSPHORUS, FAT AND AMINO ACID CONTENT OF 44% S. B. MEAL, 48% S. B. MEAL AND 50% MEAT AND BONE MEAL. WHEN ASSUMING THE AMINO ACIDS IN THE PROTEIN IN MEAT AND BONE MEAL ARE AS AVAILABLE AS THOSE IN S. B. MEAL, WE CAN CALCULATE THE COMPARATIVE NUTRITIONAL VALUE OF ALL THREE PRODUCTS BASED ON MARKET PRICE OF PROTEIN, CALCIUM AND PHOSPHORUS. I DEDUCTED FOR 4.5 LBS. OF SYNTHETIC LYSINE THAT WAS REQUIRED TO BRING 50% M. & B. MEAL LYSINE CONTENT (2.89%) TO 48% S. B. MEAL'S 3.1% LEVEL.

AFTER ANALYZING TABLE I, WE COULD CONCLUDE THAT 50% M. & B. MEAL SHOULD HAVE BEEN SELLING FOR $83.32 AND $54.49 OVER 44% S. B. MEAL AND 48% S. B. MEAL, RESPECTIVELY, RATHER THAN $19.00 AND $1.50. THE RENDERING INDUSTRY HAS NOT ENJOYED THAT TYPE OF DIFFERENTIAL FOR MANY YEARS. EITHER MEAT AND BONE MEAL IS SELLING BELOW IT'S THEORETICAL NUTRITIONAL VALUE FOR SWINE DIETS OR THERE ARE FACTORS THAT ARE RESTRICTING ITS PROPER UTILIZATION. WE WILL DISCUSS THESE ITEMS LATER, BUT FOR NOW WE WILL FORMULATE TWO SWINE GROWING RATIONS IN TABLES II AND III. TABLE II WILL UTILIZE MEAT AND BONE MEAL TO THE EXTENT THAT THE PHOSPHORUS REQUIREMENT IS MET BY THE COMBINATION OF TWO-THIRDS 48% S. B. MEAL AND ONE-THIRD 50% M. & B. MEAL. TABLE III WILL BE A TYPICAL CORN-SOYBEAN MEAL GROWER RATION. WHEN ONE-QUARTER POUND OF SYNTHETIC LYSINE IS ADDED TO THE FORMULA IN TABLE II, THE LYSINE REQUIREMENT IS MET AND AFTER ADDING THE COST OF THE LYSINE TO THE DIET, IT STILL IS SIGNIFICANTLY CHEAPER THAN THE RATION IN TABLE III.

ALTHOUGH MBM IS USED EXTENSIVELY IN SWINE DIETS, ITS CONTENT IS USUALLY LIMITED TO 2.5 TO 3.75% OF THE DIETS OF SOWS AND GROWING-FINISHING

SWINE AND IS NOT ROUTINELY ADDED TO DIETS OF YOUNG WEINED PIGS. THESE LIMITATIONS ARE DUE TO THE PERCEPTION OF NUTRITIONISTS THAT MBM HAS VARIABLE QUALITY AND THAT USAGE OF HIGHER LEVELS WILL REDUCE PIG PERFORMANCE.

RESEARCH SPONSORED BY THE FATS AND PROTEINS RESEARCH FOUNDATION OVER MANY YEARS HAS DEMONSTRATED THAT MEAT AND BONE MEALS DO VARY IN COMPOSITION AND IN CAPACITY TO PROVIDE SOME ESSENTIAL AMINO ACIDS. THIS VARIATION APPEARS TO BE ASSOCIATED WITH STARTING MATERIALS, E.G. FALLEN ANIMALS VERSUS PACKING HOUSE VISCERA VERSUS SHOP FATS AND BONES. THE DECOMPOSITION OF THE RAW MATERIAL BEFORE COOKING AND THE MANNER OF COOKING (RETENTION TIME AND TEMPERATURE) ARE ALSO IMPORTANT FACTORS IN DETERMINING THE AMOUNT AND DIGESTIBILITY OF THE ESSENTIAL AMINO ACIDS. FROM TABLE I IT IS APPARENT THAT MEAT AND BONE MEAL HAS A LOWER VALUE OF LYSINE, HISTIDINE, ISOLEOCINE AND TRYPOTOPHAN THAN 48% SOYBEAN MEAL. SINCE CORN IS ALSO LOW IN TRYPOTOPHAN THIS AMINO ACID IS USUALLY THE SECOND LIMITING AMINO ACID AFTER LYSINE, IN SWINE RATIONS FORMULATED WITH MEAT AND BONE MEAL. NUTRITIONISTS MUST USE SOYBEAN MEAL FOR ITS TRYPTOPHAN VALUE, BUT WHEN USING N.R.C. REQUIREMENTS FOR GROWING SWINE, MEAT AND BONE MEAL SHOULD BE ABLE TO SUPPLY ONE-THIRD OF THE SUPPLEMENTAL PROTEIN, WITH ALL AMINO ACID REQUIREMENTS BEING MET WITH THE EXCEPTION OF LYSINE (TABLE II).

WHEN MEADE REPLACED ONE-THIRD OF THE SOYBEAN MEAL WITH MEAT AND BONE MEAL IN A 12% FINISHING DIET THERE WAS ONLY MINOR DEPRESSION IN DAILY GAIN AND FEED/GAIN RATIO WAS INCREASED SLIGHTLY. WHEN MEAT AND BONE MEAL REPLACED ONE-THIRD OF A 13% PROTEIN FINISHING RATION THERE WAS A 10% REDUCTION IN AVERAGE DAILY GAIN BUT THERE WAS A 5.5% IMPROVEMENT

IN THE FEED/GAIN RATIO. DR. MEADE CONCLUDED THAT THE LESS THAN OPTIMUM RESULTS ACHIEVED MAY INDICATE THAT SOME AMINO ACID, PARTICULARLY LYSINE, WAS NOT FULLY AVAILABLE FROM THE MEAT AND BONE MEAL FED IN THIS EXPERIMENT. SUFFICIENT LYSINE IS MOST IMPORTANT IN MAINTAINING OPTIMUM GAIN IN GROWING SWINE.

WHEN MEAT AND BONE MEAL IS USED AT TWO PARTS SOYBEAN MEAL TO ONE PART MEAT AND BONE MEAL RATIO IN SWINE DIETS, THE PHOSPHORUS IN MBM WILL, IN MANY CASES, MEET THE PHOSPHORUS REQUIREMENTS OF THE DIET WHEN COMBINED WITH THE CORN AND SOYBEAN MEAL PHOSPHORUS.

THE OBJECTIVES OF THIS PAPER IS TO INFORM THE RENDERER OF THE TREMENDOUS OPPORTUNITY FOR INCREASED MEAT AND BONE MEAL USAGE IN SWINE DIETS WITH JUST A SMALL IMPROVEMENT IN DIGESTIBILITY OF LYSINE AND OTHER AMINO ACIDS IN THEIR ANIMAL PROTEINS.

TO BETTER ILLUSTRATE THE ABOVE STATEMENT IS TO PICTURE YOURSELF AS A FEED NUTRITIONIST AND YOU ARE ACCEPTING THE NRC VALUES FOR FEED INGREDIENTS AND REQUIREMENTS FOR SWINE DIETS. BEFORE YOU INCLUDE THOSE VALUES IN YOUR COMPUTER, IT IS NECESSARY NOT ONLY TO LOOK AT THE LEVEL OF THE AMINO ACIDS IN THE INGREDIENTS, BUT ALSO THE DIGESTIBILITY. TABLE IV IS THE LATEST NRC VALUES FOR AVAILABILITY OF FOUR CRITICAL AMINO ACIDS IN FEEDSTUFFS USED IN SWINE DIETS. THE MOST GLARING ASPECT OF THIS DATA IS THE LOW DIGESTIBILITY LEVELS ASSIGNED FOR MEAT AND BONE MEAL.

TABLE V COMPARES THE LYSINE CONTENT OF THE SAMPLES OF MEAT AND BONE MEAL ANALYZED BY DR. KNABE AT TEXAS A & M (1989) FOR A F.P.R.F. STUDY.

THOSE SAMPLES WITH LESS THAN 50% PROTEIN HAVE LOWER LYSINE CONTENT SINCE THE COLLOGEN PROTEIN FOUND PRIMARILY IN BONES, TENDONS AND LIGAMENTS HAVE A LOWER CONTENT OF ESSENTIAL AMINO ACIDS. THE HIGHER PROTEIN SAMPLES CONTAIN MORE GLOBULAR PROTEIN (MEAT TISSUE) AND SUPPORTS A SUPERIOR AMINO ACID PROFILE. IF WE ELIMINATE ALL SAMPLES WITH LESS THAN 49.5% PROTEIN AND THOSE ABOVE 51.2%, WE FIND THE LYSINE VARIES FROM 2.56 to 3.06%. N.R.C. LISTS THE VALUE FOR MEAT AND BONE MEAL AS 2.89%. SAMPLE(H)WITH A PROTEIN OF 49.4% HAD A LYSINE LEVEL OF 2.88%. IF THE PROTEIN WAS RAISED TO 50%, ITS LYSINE VALUE WOULD BE OVER 2.9%, SLIGHTLY OVER THE N.R.C. TABLES. SAMPLE (D) WITH A PROTEIN OF ONLY 47.5% HAD A LYSINE CONTENT OF 2.72%. IF THIS PROTEIN WAS BLENDED WITH QUALITY MEAT AND BONE MEAL OVER 50% (SAMPLES G AND J) IT WOULD CONTAIN CLOSE TO THE N.R.C. VALUE OF 2.89%.

TABLE VI SHOWS THE DIGESTIBILITY OF THE SAME SAMPLES IN TABLE V. IT IS APPARENT THAT ALL SAMPLES WITH ABOVE AVERAGE LYSINE CONTENT DO NOT HAVE GOOD DIGESTIBILITIES. SOME WITH LOW LYSINE CONTENT HAVE ABOVE AVERAGE DIGESTIBILITIES.

ONE EXPLANATION IS THAT SOME RAW MATERIAL, BECAUSE OF THE MIX OF BONES, FAT TRIMMINGS, MEAT CONTENT, ETC., DO NOT HAVE A HIGH LEVEL OF LYSINE, BUT THEY WERE COOKED PROPERLY AND THE LYSINE CONTENT HAS AN ABOVE AVERAGE DIGESTIBILITY. THOSE SAMPLES WITH A HIGH LYSINE CONTENT, BUT POOR DIGESTIBILITY, COULD HAVE CONTAINED AN ABOVE AVERAGE LEVEL OF GLOBULAR PROTEIN BUT WAS SUBJECTED TO HIGHER THAN NORMAL COOKING TEMPERATURES. IN OTHER SAMPLES, THE LYSINE CONTENT AND DIGESTIBILITY

COULD HAVE BEEN DEGRADATED BY EXTREME COOKING TEMPERATURES OR MICRO-BIOLOGICAL ACTION IN THE RAW MATERIAL BEFORE COOKING.

IT IS APPARENT FROM THESE TABLES THAT THE INDUSTRY PRODUCES SOME MEAT AND BONE MEAL WITH THE SAME LYSINE CONTENT AND AVAILABILITY AS SOYBEAN MEAL PROTEIN. THE ONLY LIMITING FACTOR IN THEIR UTILIZATON IN SWINE DIETS IS THEIR MINERAL CONTENT. THEREFORE, THEY COULD SUPPLY ONE-THIRD OF THE SUPPLEMENTAL PROTEIN IN SOW, GROWING AND FINISHING DIETS. TABLE VII DEMONSTRATES THE FEEDING VALUES OF SOME LOW DIGESTIBILITY SAMPLES AND HIGH DIGESTIBLITY SAMPLES COMPARED TO A SOYBEAN MEAL CONTROL IN SWINE STARTER, GROWER AND FINISHER RATIONS.

SUGGESTIONS FOR IMPROVEMENT

1. BLEND TO 50% PROTEIN WITH ONLY HIGH AND LOW PROTEIN MEAT AND BONE MEALS, BLOOD MEAL OR POULTRY BY-PRODUCT MEAL.
2. BLEND FOR CALCIUM, PHOSPHORUS CONTENT ALONG WITH PROTEIN, BY UTILIZING DICALCIUM PHOSPHATE IN BLENDING PROCESS.
3. COOK RAW MATERIAL AS QUICKLY AS POSSIBLE AND AT THE LOWEST TEMPERATURE NECESSARY TO DESTROY ALL PATHOGENIC MICROORGANISMS IN RAW MATERIAL (190^{o}F for 30 minutes).
4. IF FINISH MATERIAL IS CLOSE TO 50% PROTEIN, MIX THE GROUND FINISH PRODUCT FROM ONE SHIFT, WITH OTHER SHIFTS' PRODUCTION. THIS CAN BE DONE IN A SILO (NOT THE BEST) OR BY HOLDING DIFFERENT SHIFTS' PRODUCTION IN SEPARATE TANKS AND BLEND IN BATCH OR CONTINUOUS MIXER. THIS SAME PROCESS COULD BE USED IN BLENDING DIFFERENT DAY'S PRODUCTION.
5. IF YOU DETERMINE THAT YOUR LOW PROTEIN PRODUCTION HAS A BELOW AVERAGE DIGESTIBILITY, GIVE CONSIDERATION TO USING BLOOD MEAL

(HIGH LYSINE AND EXCELLENT DIGESTIBILITY) TO BLEND UP TO 50% ALONG WITH USING SOME SYNTHETIC LYSINE. IN AN ATTEMPT TO ACHIEVE THE PROPER NUTRITIONAL SPREAD BETWEEN 48% S.B. MEAL AND M. & B. MEAL, RENDERERS CAN USE SEVERAL POUNDS OF SYNTHETIC LYSINE AND BLOOD MEAL TO IMPROVE THEIR PRODUCT'S LYSINE CONTENT AND DIGESTIBILITY. THIS WILL BE COST EFFECTIVE IF YOU IMPROVE THE VALUE OF YOUR PRODUCT SUFFICIENTLY FOR THE LYSINE AND MOVE CLOSER TO THE PROPER NUTRITIONAL DIFFERENTIAL AS ILLUSTRATED IN TABLE I.

6. MAINTAIN A NORMAL MOISTURE CONTENT (5 TO 7%) OF THE FINISHED PRODUCT TO INHIBIT SALMONELLA GROWTH. CONTINUALLY MONITOR YOUR PRODUCTION FOR SALMONELLA AND USE INFORMATION FROM THE A.P.P.I. SALMONELLA EDUCATION/REDUCTION PROGRAM TO PREVENT RECONTAMINATION OF YOUR FINISHED PRODUCTS.
7. POULTRY BY-PRODUCT MEAL HAS BEEN FOUND TO BE FAIRLY UNIFORM IN NUTRIENT CONTENT AND DIGESTIBILITIES OF PROTEIN AND AMINO ACIDS. DIGESTIBILITIES ARE HIGH AND EQUIVALENT TO SOYBEAN MEAL.
8. THE INDUSTRY NEEDS A QUICK AND ACCURATE (SENSITIVE) <u>IN VITRO</u> DIGESTIBILITY TEST. WE HAVE BEEN WORKING ON THIS ISSUE FOR MANY YEARS AND HOPEFULLY WE WILL BE EXPERIMENTING IN 1990 WITH A METHOD SUPERIOR TO THE PRESENT PEPSIN TEST.

TABLE I

	44% Soybean Meal			48% Soybean Meal			50% M. & B. Meal		
	Per Cent	Cost Per Unit	Value Per Ton	Per Cent	Cost Per Unit	Value Per Ton	Per Cent	Cost Per Unit	Value Per Ton
Protein	44.0	$ 5.36	$236.00 (1)	48.0	$5.28	$253.50 (1)	50.9	$ 5.10	$255.00 (1)
Fat	1.1	.12	2.64 (2)	.9	.12	2.16 (2)	9.4	.12	23.28 (2)
Fiber	7.3	.0	.0	3.4	.0	.0	2.4	.0	.0
Calcium	.3	.025	.02	.26	.025	.13	9.0	.025	4.50
Phosphorus	,65	13.20	8.58	.64	13.20	8.45	4.2	13.20	55.44
M.E. Pkg.	3220			3385			2280		
Arginine	3.20			3.67			3.65		
Histidine	1.12			1.20			0.96		
Isoleucine	2.60			2.13			1.47		
Leucine	3.37			3.63			3.02		
Lysine	2.90			3.12			2.89		
Methionine	0.52			0.71			0.68		
Cystine	0.66			0.72			0.46		
Phenylalanine	2.10			2.36			1.65		
Tyrosine	1.50			1.71			0.79		
Threonine	1.70			1.90			1.60		
Tryptophan	0.64			0.69			0.28		
Valine	2.20			2.47			2.14		

VALUE OVER 48% SOYBEAN MEAL

(3) $5.28 x 2 = $10.56. To increase M. & B. Meal's lysine content level to the same as 48% S.B. Meal (3.1%) would take 4.5 lbs. of synthetic lysine per ton. 4.5 lbs. x $1.65=$7.43
$10.56 minus $7.43 = $3.13
4.37
46.99

Total= $54.49

(1) Based on Cash Market Comparisons Feedstuff-March 6, 1989.

(2) Fat content of M. & B. Meal contributes to it's M.E. value. Since M. & B. Meal has a lower metabolizable energy value than S.B. Meal, we can't include it's value other than for dust control.

(3) Calculated extra protein in M. & B. Meal at same value of 48% S.B. Meal less difference in lysine level of M. & B. meal versus 48% S.B. Meal (7%).

TABLE II

Ingredients	Pounds	Protein	Ca	P	Arginine	Histidine	Isoleucine	Leucine	Lysine	Cystine) Methionine)	Tyrosine) Phenylalanine)	Threonine	Tryptophan	Valine	M.E.Kcal/kg.	COST
Yellow Corn	1625	138	.48	4.55	7.0	4.4	5.7	19.4	4.1	6.5	11.1	5.8	1.5	7.8	55575	81.25
48% S.B. Meal	235	113	.61	1.50	8.6	2.8	5.0	8.5	7.3	3.3	9.56	4.5	1.6	5.8	7955	29.79
50% M.& B. Meal	115	58	10.35	4.83	4.2	1.1	1.7	1.7	3.5	1.3	2.8	1.84	.32	2.5	2622	14.66
Vitamin Pre-Mix	25	0	1.14		- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Total	2000	15.5	.63	.54	.98	.41	.62	1.5	.74	.56	1.2	.60	.17	.81	3307	125.70
Requirements for 40-100 lb.Growing Pig	2000	15.0	.60	.50	.25	.22	.46	.60	.75	.41	.66	.48	.12	.48	3250	

TABLE III

Ingredients	Pounds	Protein	Ca	P	Arginine	Histidine	Isoleucine	Leucine	Lysine	Cystine / Methionine	Tyrosine / Phenylalanine	Threonine	Tryptophan	Valine	M.E. Kcal/kg	COST
Yellow Corn	1569	133.2	.47	4.4					3.93				1.42		53797	$ 78.40
48% S.B. Meal	368	176.6	.95	2.3					11.39				2.52		12355	46.64
Vitamin Pre-Mix	25	0	1.14	0					0						0	
Dicalcium Phos.	23	0	4.8	4.3					0						0	2.81
Calcium Carbonate	15	0	5.7	0					0						0	.38
Total	2000	15.5	.65	.55					.76				.20		3307	128.23
Requirements for 40-100 lb. Growing Pig		15	,6	.50					.75				.12		3250	

TABLE IV

TABLE 6-6 Apparent Ileal Digestibilities of Selected Amino Acids in Swine Feedstuffs

Feedstuff	Amino Acid (%)			
	Lysine	Tryptophan	Threonine	Methionine
Barley, grain	73	73	70	82
Beans, broad (*Vicia faba*)	82	68	75	73
Blood meal	81		82	
Canola meal	75		67	84
Corn, dent yellow, grain	80	70	73	80
Cottonseed meal, solvent	65	73	63	70
Fish meal	80		76	84
Meat and bone meal	64	53	56	73
Oat groats	82	81	78	89
Oats	58	59	53	75
Peanut meal	79			
Rye, grain	68	62	62	80
Sorghum grain (milo)	80	75	73	85
Soybean meal, dehulled, solvent	85	78	74	88
Soybean meal, solvent	87	81	77	80
Triticale	82		74	85
Sunflower meal	72		71	84
Wheat	80	78	74	85

NOTE: Values represent the percentage of the total amino acid contained in the feedstuff that has disappeared from the digestive tract of growing swine when digesta arrive at the terminal ileum. No adjustments have been made for the effects of the contributions of amino acids from endogenous sources. Blank spaces indicate that data are not available.

SOURCE: Derived from (see Protein and Amino Acids section of the References chapter) Danksley and Kumbe (1994), Sauer and Ozimek (1986), and Batterham and Tavernor (1987).

TABLE V

TABLE 2. ANALYZED CONTENT OF THE MEAT AND BONE MEALS

			PERCENTAGE																
TRIAL	MEAL	PROCESS	CRUDE PROTEIN	ASH	ARG	HIS	ILE	LEU	LYS	PHE	THR	TRP	VAL	ALA	ASP	GLU	GLY	PRO	SER	TYR
1	A	CG	53.5	21.1	3.72	0.90	1.87	3.62	2.78	1.90	1.99	0.25	2.65	3.83	4.17	7.15	6.90	4.61	2.81	1.19
1	B	B	52.8	24.2	3.73	0.84	1.90	3.70	2.50	1.86	1.95	0.26	2.77	3.87	4.12	6.75	7.03	5.03	2.83	1.09
1	C	D	54.0	24.1	3.90	0.99	1.58	3.31	2.88	1.36	1.67	0.23	2.37	4.48	4.22	7.07	8.57	5.36	1.80	0.96
2	D	SB	47.5	23.6	3.25	0.84	1.47	2.97	2.72	1.58	1.59	0.24	2.02	3.63	3.69	5.82	6.63	3.41	1.89	1.07
2	E	CG	47.6	29.7	3.32	0.73	1.44	3.08	2.63	1.64	1.62	0.22	2.78	3.63	3.66	5.81	6.69	2.44	2.09	1.05
2	F	B	49.8	30.4	3.55	0.70	1.50	3.09	2.58	1.58	1.60	0.22	2.08	3.85	3.69	6.27	7.36	4.43	1.91	1.09
3	G	A	54.9	22.2	3.68	1.36	1.89	3.62	3.47	1.94	1.92	0.34	2.55	4.01	4.39	7.02	6.76	4.23	2.23	1.33
3	H	SB	49.4	26.2	3.32	1.07	1.54	3.06	2.88	1.63	1.63	0.28	2.16	3.70	3.76	6.05	6.73	4.03	1.98	1.10
3	I	B	45.6	28.0	3.16	0.88	1.37	2.69	2.51	1.46	1.47	0.23	1.91	3.47	3.42	5.56	6.72	3.97	1.85	0.98
4	J	CG	52.2	20.1	3.52	1.26	1.65	3.36	3.20	1.90	1.89	0.31	2.50	3.65	4.13	6.71	6.03	3.59	2.35	1.29
4	K	CG	49.0	26.2	3.46	0.96	1.40	2.81	2.63	1.55	1.58	0.26	1.99	3.66	3.62	5.93	7.09	4.14	1.94	1.04
4	L	B	54.2	20.6	3.73	1.06	1.98	3.66	2.75	2.01	1.99	0.30	2.79	3.80	4.06	6.80	6.69	4.33	3.04	1.32
5	M	A	53.0	26.1	3.72	1.12	1.62	3.54	3.15	1.91	1.85	0.34	2.37	4.03	4.31	6.93	6.96	3.81	2.15	1.27
5	N	CG	48.0	27.5	3.45	0.87	1.43	2.93	2.65	1.51	1.61	0.26	1.98	3.58	3.73	5.96	6.60	3.98	1.86	1.06
5	O	B	46.2	30.7	3.27	0.62	1.20	2.58	2.20	1.33	1.40	0.22	1.82	3.51	3.35	5.50	7.10	4.24	1.76	0.93
5	P	SB	50.4	30.3	3.54	0.90	1.38	3.13	2.70	1.83	1.64	0.30	2.12	3.79	3.81	6.04	7.12	4.27	1.98	1.10
6	Q	D	45.4	32.7	3.21	0.93	1.28	2.66	2.50	1.66	1.46	0.23	2.09	3.56	3.41	5.33	6.67	4.13	1.84	0.96
6	R	CG	48.5	24.0	3.36	1.09	1.38	2.81	2.63	1.59	1.64	0.27	2.09	3.64	3.77	6.08	6.62	4.10	1.89	1.08
6	S	D	50.3	26.4	3.52	1.14	1.27	2.88	2.80	1.68	1.56	0.27	2.21	4.01	3.78	6.05	7.49	4.62	1.83	1.04
7	T	D	50.9	28.9	3.58	0.95	1.59	3.14	2.76	1.62	1.66	0.27	2.16	3.91	3.89	6.41	7.18	4.30	1.90	1.12
7	U	D	51.2	25.3	3.83	1.10	1.71	3.47	3.06	1.82	1.82	0.31	2.40	4.18	4.28	6.97	7.25	4.43	2.01	1.26
7	V	SB	49.6	19.9	3.39	0.85	1.67	3.40	2.56	1.82	1.80	0.29	2.51	3.54	3.84	6.29	6.09	4.30	2.55	1.24
7	W	D	48.8	24.9	3.51	0.76	1.39	2.82	2.44	1.48	1.51	0.23	1.94	3.73	3.74	6.04	7.46	4.54	1.86	1.03
AVERAGE			50.1	25.8	3.51	.95	1.54	3.14	2.74	1.68	1.69	.27	2.27	3.79	3.86	6.28	6.94	4.18	2.10	1.11
STANDARD DEVIATION			2.8	3.6	.21	.18	.22	.35	.28	.19	.18	.04	.30	.24	.30	.54	.51	.56	.37	.12
MINIMUM			45.4	19.9	3.16	.62	1.20	2.58	2.20	1.33	1.40	.22	1.82	3.47	3.35	5.33	6.03	2.44	1.76	.93
MAXIMUM			54.9	32.7	3.90	1.36	1.98	3.70	3.47	2.01	1.99	.34	2.79	4.48	4.39	7.15	8.57	5.30	3.04	1.33

As fed basis. Free molecular weights were used to calculate the percentage of amino acids.

Processing methods: A=Atlas, B=batch, CG=Carver-Greenfield, D=Dupps and SB=Stordz-Bards

TABLE 5. APPARENT ILEAL AND FECAL DIGESTIBILITIES OF NITROGEN AND APPARENT ILEAL DIGESTIBILITIES OF AMINO ACIDS IN MEAT AND BONE MEAL

			PERCENTAGE															
TRIAL	MEAL	PROCESS	ILEAL N	FECAL N	ARG	HIS	ILE	LEU	LYS	PHE	THR	TRP	VAL	ALA	ASP	GLU	GLY	SER	TYR
1	A	CG	75	81	84	72	81	82	79	84	75	65	80	79	67	76	74	71	80
1	B	B	65	81	79	69	73	73	67	76	66	51	72	71	46	66	60	64	67
1	C	D	60	79	79	58	67	70	61	76	59	35	68	71	39	65	67	56	66
2	D	SB	73	83	86	74	75	79	80	85	71	61	79	80	60	80	76	75	72
2	E	CG	67	77	77	71	59	73	71	77	64	53	72	74	61	70	74	68	66
2	F	B	57	74	73	53	55	63	56	70	51	41	60	66	36	61	63	52	55
3	G	A	67	82	80	73	63	76	75	80	66	65	74	76	54	74	71	65	75
3	H	SB	69	81	82	73	61	76	76	81	67	62	75	79	56	76	75	67	76
3	I	B	63	80	78	66	58	71	67	78	61	65	70	72	48	70	67	64	77
4	J	CG	71	84	83	79	71	82	81	86	71	74	80	79	67	77	72	70	84
4	K	CG	72	81	85	72	68	80	79	84	71	67	78	81	68	79	77	72	83
4	L	B	61	79	77	67	62	70	69	78	60	55	69	71	43	66	63	62	72
5	M	A	65	80	80	66	73	77	73	80	62	56	75	76	48	73	66	63	77
5	N	CG	72	83	80	78	77	81	80	82	73	67	79	77	70	78	70	71	81
5	O	B	66	78	78	51	67	73	65	75	63	57	73	72	49	68	67	61	72
5	P	SB	65	78	74	75	71	75	74	79	65	65	74	71	54	70	65	64	74
6	Q	D	58	76	75	63	57	70	65	69	54	45	65	69	45	65	64	54	50
6	R	CG	60	79	79	65	63	73	65	74	61	50	70	71	48	69	63	60	62
6	S	D	61	82	76	65	62	69	63	73	59	56	69	70	48	65	62	58	56
7	T	D	60	81	80	68	68	74	69	75	58	58	70	71	45	66	64	58	65
7	U	D	54	79	76	61	58	67	60	70	49	49	63	66	30	61	56	48	58
7	V	SB	68	82	82	74	75	76	75	80	66	64	76	76	57	73	68	69	73
7	W	D	71	86	88	74	73	81	76	82	67	65	78	81	55	77	74	69	74
AVERAGE			65	80	80	68	67	74	71	78	63	58	73	74	52	71	68	64	71
STANDARD DEVIATION			5.7	2.7	3.8	7.3	7.2	5.1	7.3	4.8	6.7	9.4	5.5	4.6	10.5	5.8	5.6	6.9	9.3
MINIMUM			54	74	73	51	55	63	56	69	49	35	60	66	30	61	56	48	50
MAXIMUM			75	86	88	79	81	82	81	86	75	74	80	81	70	80	77	75	84

Values for each meal are means of 4 or 5 observations. Each trial followed a 4x4 or 5X5 Latin square design. Soybean meal was also evaluated in each trial.

Processing methods: A=Atlas, B=batch, CG=Carver-Greenfield, D=Dupps and SB=Stordz-Bards

TABLE 10. PERFORMANCE OF STARTER, GROWER AND FINISHER SWINE FED DIETS CONTAINING MEAT AND BONE MEALS WITH LOW OR HIGH DIGESTIBILITY[a]

	Meat and bone meal		Soybean meal
	Low Digest.[b]	High Digest.[c]	control
Starter[d]			
Daily gain, lb	.90	.95	.96
Feed intake, lb	1.63	1.64	1.66
Feed/gain	1.81[g]	1.72[h]	1.72[h]
Grower[e]			
Daily gain, lb	1.80[i]	1.91[j]	1.94[j]
Feed intake, lb	4.67	4.67	4.74
Feed/gain	2.58[k]	2.44[l]	2.45[l]
Finisher[f]			
Daily gain, lb	2.05	2.18	2.17
Feed intake, lb	7.05	7.06	7.14
Feed/gain	3.45[k]	3.24[l]	3.31[l]

[a]Diets were formulated to contain the same amount of total lysine. Crystalline tryptophan was added to meat and bone meal diets to ensure nutritional adequacy.

[b]Mixture of meat and bone meals C and F to contain 2.75% total lysine and 1.62% digestible lysine (59% lysine digestibility).

[c]Mixture of meat and bone meals A and D to contain 2.75% total lysine and 2.20 digestible lysine (74% lysine digestibility).

[d]Meat and bone meal diets contained 10% meat and bone meal. Values are means for four pens of six pigs each. Average initial weight was 15 lb and the trial lasted 38 days.

[e]Meat and bone meal diets contained 5% meat and bone meal. Values are means for nine pens of two pigs each. Average initial weight was 49 lb.

[f]Meat and bone meal diets contained 4% meat and bone meal. Values are means for nine pens of two pigs each. Average initial weight was 127 lb.

[gh]Values not sharing a common superscript differ (P=.08).

[ij]Values not sharing a common superscript differ (P=.06).

[kl]Values not sharing a common superscript differ (P=.01).

TABLE VIII

Effect of hydrolyzing blood with feathers on protein bypass and digestibility.

Protein source	Bypass[a]	Digestibility[b]	Net Bypass[c]
Soybean meal	26[d]	100[e]	26
Blood + raw feathers hydrolyzed, ring dried	76[e]	87[d]	63
Blood + hydrolyzed feathers then ring dried	82[f]	96[e]	78
Blood meal	90[g]	100[e]	90
Feather meal	73[e]	96[e]	69

[a]Bypass determined as percentage of protein remaining after 12 hours of ruminal incubation in dacron bags.
[b]Total tract digestibility determined in lambs.
[c]Net bypass = Bypass - indigestibility.
[d,e,f,g]Means within columns with unlike superscripts differ (P<.07).

Figure 1.
Protein Efficiency of Calves Fed Soybean Meal (SBM) Feather meal (FTH) and Blood Meal (BM).