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FORMULATING SWINE AND POULTRY RATIONS USING FLASH DRIED BLOOD MEAL

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Introduction

Blood meal consists of the solids from primarily the cellular portions of the blood of slaughter animals. The major constituent in blood meal is hemoglobin. In addition, blood meal contains fibrinogen and blood cell membrane proteins plus cellular electrolytes and small amounts of fat and carbohydrates (table 1). Blood meal processed by some newer procedures contains all of the solids, cellular and plasmal, of whole blood. The principal nutritional interest in blood meal is because of its high protein content and in particular its high content of the critically limiting amino acid, lysine. Blood meal has found limited use in livestock rations in the past because extended vat-drying procedures resulted in a product of poor palatability and poor bioavailability of its lysine. Newer flash drying procedures have improved both the palatability and the lysine bioavailability of blood meal.

The purpose of this paper is to present information from studies of the nutritional evaluation of flash dried blood meal and to suggest uses of this ingredient in formulating diets for swine and poultry.

Nutritional evaluation: bioavailable lysine

Titus *et al*. (1936) and Morrison (1957) reported blood meal to be unpalatable to swine and poultry and inferior to other animal proteins in value. Grau and Almquist (1944) showed that the plasma fractions of beef blood are of better protein quality than the cellular fractions in which isoleucine was the principal limiting amino acid.

Table 1. A comparison of the nutrient composition of conventional blood meal (CBM)* and dehulled soybean meal (DSM)*

Nutritional entity	CBM	DSM	Element	CBM	DSM	Amino Acid	CBM	DSM
Dry matter, %	89.3	91.3	Ca, %	.30	.29	Arg	3.2	3.4
Crude protein, %	80.2	50.8	P, %	.23	.65	Gly	4.5	2.7
Ash, %	4.4	5.9	K, %	.09	2.05	His	3.8	1.3
Crude fiber, %	0.6	2.9	Na, %	.31	.34	Iso	0.9	2.5
Ether extract, %	1.4	1.1	Cl, %	.26	.03	Leu	9.9	3.8
N-free extract, %	2.7	30.5	Mg, %	.21	.27	Lys	5.4	3.1
Gross energy, Kcal/g	5.05	4.25	S, %	.32	.43	Met	1.0	0.7
DE, swine, Kcal/kg	2475	4007	Fe, ppm	3600	100	Cyst	1.4	0.7
ME, swine, Kcal/kg	1927	3542	Mn, ppm	5.2	27.3	Phe	5.2	2.5
ME, chicken, Kcal/kg	2845	2489	Cu, ppm	9.7	14.2	Thr	3.9	2.0
						Try	1.0	0.6
						Val	6.9	2.5

*Atlas of nutritional data on U.S. and Canadian feeds (1971).

Squibb and Braham (1955) found blood meal to be a satisfactory source of lysine in chick rations at levels of 2 to 4 percent. Becker et al. (1957, 1963) used blood flour at 15 to 30 percent levels in semi-purified diets to study the isoleucine requirement of baby, weanling and finishing pigs. Acceptable growth was obtained when the isoleucine requirement was met. Meade and Teter (1957) improved performance of growing pigs on meat and bone meal rations by substituting blood meal or soybean meal for one-half of the supplemental protein supplied by meat and bone meal.

Availability of lysine in vat-dried commercial blood meal and soluble blood meal spray dried at 145°F was evaluated by Kratzer and Green (1957). In chick and poult assays they found 68 to 85 percent lysine availability in the spray dried blood meal and 49 to 66 percent lysine availability in the vat-dried blood meal. In recent research Waibel (1974) and Waibel, Carpenter and Behrends (1974) compared the chemical and biological availability of ring-dried and vat-dried blood meal. Conventional vat-dried blood meal had chemical (fluorodinitro benzene) and biological (poult assay) lysine availabilities of 80 and 49 percent, respectively. Corresponding values for ring-dried blood meal were 86 and 83 percent, respectively. Waibel's data indicated that when chemical availability of lysine in a blood meal fell below 85 percent, the biological availability fell with increasing severity.

Our studies (Parsons et al., 1975 and Miller et al., 1976a) have dealt with the bioavailability of lysine of ring dried cattle and pig blood in pig assays. The initial study was conducted using young pigs weighing 13 kg and with basal diet A of table 2. Substitutions of 0.1 and 0.2 percent L-lysine and 1.5 and 3.0 percent of ring dried cattle blood (RDCB) for the appropriate amount of corn starch in basal diet A were made. This pig assay gave RDCB a lysine value of 6.8 percent or 70 percent bioavailability of the 9.7 percent total lysine in RDCB. Nitrogen and energy balance trials with the basal diet or with 1.5 or 3 percent RDCB incorporated into the basal diet gave the results summarized in table 3. These data demonstrate the improvement of dietary protein utilization from the lysine of the added RDCB. The data demonstrate also that replacement of corn starch with RDCB tended to increase the digestible and metabolizable energy density in the diet.

Basal diet B of table 2 was used in a second study to compare the bioavailability of lysine in ring dried pig blood (RDPB) with that of RDCB (using pigs weighing 9 kg in a 4 week assay). Both RDPB (Wilson & Co., Logansport, Indiana) and RDCB (Van Hoven Co., Inc., South St. Paul, Minnesota) analyzed 9.7 percent total lysine. This pig assay gave both RDPB and RDCB lysine values of 6.7 percent or 69 percent bioavailability of the lysine. Basal diet C was used to assay the bioavailable lysine in another flash dried blood meal from cattle blood using a steam drum drying procedure (Overton Machine Co., Dowagiac, Michigan). While the total lysine in this blood meal was somewhat lower (8.8 percent) than that of the ring dried blood meals (9.7 percent), the bioavailable lysine value (6.6 percent) was similar to that assayed for the ring dried blood meals (6.7 percent).

Nutritional evaluation: feeding trials

From the pig assays we were convinced that we could assign a lysine value of 7.0 percent to flash dried blood meal and safely

Table 2. Basal diets used in bioavailable lysine assays

Ingredient	A	B	C
Corn starch	3.0	3.0	3.0
Ground shelled corn	82.3	78.65	80.64
Dehulled soybean meal	11.5	15.0	13.0
Dicalcium phosphate	1.0	1.0	1.0
Calcium carbonate	1.0	1.0	1.0
Salt	0.5	0.5	0.5
Vitamin-trace mineral mix[a]	0.5	0.5	0.5
Antibiotic mix	0.2[b]	0.25[c]	0.25[c]
DL-methionine	0	0.1	0.1
L-tryptophan	0	0	0.01
	100.00	100.00	100.00
<u>Calculated analyses</u>			
DE, Kcal/kg	3450	3450	3450
Crude protein, %	13.0	14.0	13.4
Ca, %	0.66	0.67	0.67
P, %	0.50	0.51	0.50
Lys, %	0.55	0.65	0.60
Met & Cys, %	0.46	0.58	0.56
Try, %	0.13	0.15	0.15

[a]Supplying per kg of complete diet: vitamin A, 3300 Iu; vitamin D, 660 IU; vitamin E, 11 IU; menadione sodium bisulfite, 2.2 mg; riboflavin, 3.3 mg; nicotinic acid, 17.6 mg; D-pantothenic acid, 13.2 mg; choline, 110 mg; vitamin B_{12}, 19.8 mcg;zinc, 75 mg; iron, 60 mg; manganese, 37 mg; copper, 10 mg; iodine, 2 mg; selenium, 0.1 mg.

[b]Supplying 44 mg chlortetracycline per kg of complete diet.

[c]Supplying 110 mg chlortetracycline, 110 mg sulfamethazine and 55 mg penicillin per kg of complete diet.

Table 3. Protein and energy evaluation of diets with different levels of ring dried cattle blood (RDCB)

Diet	NPU[a]	DE[b]	ME[c]	N corrected ME[d]
Basal	62	3366	3332	3321
Basal & 1.5% RDCB	73	3426	3399	3385
Basal & 3% RDCB	67	3444	3412	3400

[a]Net protein utilization, %.

[b]Digestible energy, kcal/kg.

[c]Metabolizable energy, kcal/kg

[d]Nitrogen corrected metabolizable energy, kcal/kg.

incorporate this ingredient at limited levels into linear programmed swine starter, grower and finisher diets to meet the specifications shown in table 4. Thus, assigning lysine values of 0.25 percent to corn, 3.1 percent to dehulled soybean meal and 7.0 percent for ring dried pig blood and other estimated nutrient values for these and other ingredients, starter, grower and finisher diets with three levels of RDPB were formulated to test the validity of this assumption. The control corn-soybean meal diets used in the trial are given in table 5. Test diets of 3 and 6 percent RDPB in the starter phase (8 to 25 kg), 2 and 4 percent RDPB in the grower phase (25 to 55 kg) and 1.5 and 3 percent RDPB in the finisher phase (55 to 95 kg) were also formulated to meet specifications in table 4.

The results of combined replicates measuring growth and feed efficiency during the starting, growing and finishing periods are summarized in table 6. The performance of all treatments in each category of growth was almost identical, giving confidence in the lysine and other nutrient values assigned to the flash dried blood meal (RDPB). Carcass data from pigs slaughtered at the end of this study are given also in table 6. Here, as well, parameters reveal the similarity of body composition of pigs reared on the three different levels of blood meal in the diet. Wahlstrom and Libal (1976) recently reported good performance when flash dried blood meal was incorporated at 5.7 percent in the swine grower diet and 4 percent in the swine finisher diet.

<u>Economic evaluation</u>

The economic value of flash dried blood meal in swine and poultry diets is calculated primarily on the basis of its ability

Table 4. Specifications for swine starter, grower and finisher diets*

Item	Starter	Grower	Finisher
DE, kcal/lb	1550	1550	1550
Lysine, %	.95	.75	.58
Met + Cys, %	.6	.5	.4
Tryptophan, %	.18	.15	.12
Calcium, %	.6 to .8	.5 to .7	.5 to .7
Phosphorus, %	.6	.5	.5

*Miller, Miller and Ullrey (1975).

Table 5. Control corn-soybean starter, grower and finisher diets

Ingredient	Starter	Grower	Finisher
Ground shelled corn	716.5	789.5	851
Dehulled soybean meal	250	180	120
Defluorinated phosphate	15	10	11
Calcium carbonate	6	8	7
Salt	5	5	5
MSU Vit-trace min. mix[a]	5	5	5
Aureo SP-250	2.5	2.5	1
	1000.0	1000.0	1000
Calculated analyses			
DE, kcal/lb	1560	1570	1570
Crude protein, %	18.5	15.8	13.3
Calcium, %	0.78	0.69	0.66
Phosphorus, %	0.62	0.50	0.50
Lysine, %	0.95	0.75	0.58
Met + Cys, %	0.60	0.53	0.46
Tryptophan, %	0.21	0.17	0.14

[a]See footnote of table 2 for composition.

Table 6. Performance and carcass data of pigs reared on corn-soybean meal diets or diets containing low or high levels of ring-dried pig blood (RDPB)*

Measure	Diet: Corn-Soy	Diet: Low RDPB	Diet: High RDPB
Starter phase (5 weeks)			
Initial weight, lb	18.2	17.7	18.0
Average daily gain, lb	0.98	1.07	1.01
Feed/gain	2.35	2.30	2.35
Grower phase (6 weeks)			
Initial weight, lb	56.5	59.3	57.0
Average daily gain, lb	1.57	1.50	1.58
Feed/gain	3.02	3.05	3.00
Finisher phase (8 weeks)			
Initial weight, lb	127	125	128
Average daily gain, lb	1.54	1.51	1.53
Feed/gain	3.99	3.59	3.86
Slaughter data			
Live weight, lb	206	205	208
Carcass weight, lb	152	149	155
Dressing percent	73.7	72.7	74.5
Carcass length, in	30.4	30.4	30.6
Backfat, in	0.99	1.01	0.95
Percent Ham & Loin	42.3	43.3	41.2

*Miller *et al*. (1976b).

to supply metabolizable energy and critically limiting amino acids in typical corn-soybean meal diets. In this regard, a combination of 40 kg of flash dried blood meal and 60 kg of corn are nearly equivalent in metabolizable energy, lysine, methionine plus cystine, and tryptophan to 100 kg of dehulled soybean meal. When dehulled soybean meal is 22 cents per kg and corn is 11 cents per kg, flash dried blood meal is worth about 38 cents per kg.

The economic value of flash dried blood meal in ruminant diets would be calculated on its ability to supply metabolizable energy and nitrogen to the diet. In this regard a combination of 1 kg of urea and 3 kg of corn is nearly equivalent to the energy and nitrogen in 3 kg of flash dried blood meal. When urea is 20 cents per kg and corn is 11 cents per kg, flash dried blood meal is worth only about 18 cents per kg. Thus, the economic value of flash dried blood meal is much less for the ruminant and directs its use toward its greater value in non-ruminant diets.

Flash dried blood meal would be of considerable value in the diets of pets as well as in the human dietary although there are technical standards which economically eliminate it from the human diet in this country.

Using data from the Economic Research Service of USDA for the 1975 slaughter of cattle and calves, sheep and lambs, and hogs and estimating average slaughter weights in each category and using a value of 3.5 percent of body weight as bleedable blood one may calculate approximately 2 billion pounds as the annual potential U.S. bleedable blood. Since blood is 20 percent solids, this amounts to a potential of 400 million pounds or 200 thousand tons of blood meal. A current conservative value of flash dried blood meal in non-ruminant diets is $300 per ton. Thus, the potential value of flash dried blood meal from U.S. animal slaughter annually for use in swine and poultry diets is $60 million.

Formulations using flash dried blood meal (FDBM)

The following tables contain suggested formulations of swine and poultry diets meeting NRC (1971, 1973) requirements.

A. Swine Rations using FDBM

Ingredient	Starter	Grower	Finisher	Gestation	Lactation
Ground shelled corn	1590	1700	1782	1774	1694
Dehulled soybean meal	220	160	100	100	160
Flash dried blood meal	120	80	60	60	80
Dicalcium phosphate	38	28	28	30	30
Calcium carbonate	16	16	14	20	20
Salt	6	6	6	6	6
Vitamins & trace minerals[a]	10	10	10	10	10
Antibiotics	+	+	-	-	+
	2000	2000	2000	2000	2000
Calculated analyses					
DE, kcal/lb	1550	1560	1560	1550	1550
Crude protein, %	17.2	14.5	12.6	12.6	14.5
Ca, %	0.80	0.71	0.70	0.76	0.77
P, %	0.63	0.50	0.50	0.54	0.55
Lysine, %	0.95	0.75	0.58	0.58	0.75
Met + Cys, %	0.57	0.50	0.45	0.45	0.50
Tryptophan, %	0.18	0.15	0.12	0.12	0.15

[a]See footnote of table 2 for composition.

B. Chicken Rations Using FDBM

Ingredient	Broiler 0-7 wks	Starter 0-5 wks	Grower 5-12 wks	Developer 12-20 wks	Layer-Breeder
Flash dried blood meal	80	80	80	40	80
Ground shelled corn	1235	1310	1301	1305	1459
Dehulled soybean meal	350	300	200	80	150
Corn gluten meal (60%)	80	0	0	0	0
Alfalfa meal (17%0	0	50	50	50	40
Meat and bone meal (50%)	80	60	60	75	50
Dried whey	30	40	0	0	40
Oats	0	100	250	250	0
Wheat middlings	0	0	0	150	0
Stabilized fat	80	0	0	0	10
Salt	8	5	5	5	5
Dicalcium phosphate	19	25	30	25	25
Calcium carbonate	14	16	10	10	130
Vitamins & trace minerals	12[a]	10[a]	10[a]	10[a]	10[b]
Additives-antibiotic & coccidiostat	10	2	2	0	0
DL-methionine	2	2	2	0	1
	2000	2000	2000	2000	2000
Calculated analyses					
ME, kcal/lb.	1450	1360	1350	1310	1330
Crude protein, %	22.4	19.7	17.7	14.4	15.6
Fat, %	7.0	3.3	3.5	3.8	3.3
Fiber, %	2.1	2.6	3.9	4.2	2.2
Ca, %	0.98	1.01	0.94	0.94	3.10
Total P, %	0.70	0.70	0.72	0.72	0.62
Available P, %	0.50	0.50	0.52	0.52	0.46
Arginine, %	1.30	1.20	1.05	0.85	0.88
Isoleucine, %	0.93	0.82	0.72	0.61	0.63
Lysine, %	1.20	1.10	0.95	0.70	0.82
Methionine, %	0.48	0.42	0.39	0.24	0.33
Met & Cys, %	0.84	0.73	0.63	0.48	0.58
Tryptophan, %	0.22	0.21	0.18	0.14	0.16

[a]Containing per pound: vitamin A, 600,000 IU; vitamin D_3, 200,000 ICU; vitamin E, 150 IU; menadione sodium bisulfite, 150 mg; riboflavin, 375 mg; niacin, 1800 mg; pantothenic acid, 600 mg; choline chloride, 40 g; vitamin B_{12}, 0.9 mg; manganese, 1.28%; iodine, 0.02%; copper, 0.08%; cobalt, 0.005%; zinc, 1.0%; iron, 0.5%.

[b]Containing per pound: vitamin A, 800,000 IU; vitamin D_3, 250,000 ICU; vitamin E, 500 IU; menadione sodium bisulfite, 150 mg; riboflavin, 700 mg; niacin, 2500 mg; pantothenic acid, 1200 mg; choline chloride, 39g; folic acid, 100 mg; vitamin B_{12}, 1.2 mg; manganese, 1.29%; iodine, 0.02%; copper, 0.08%; cobalt, 0.005%, zinc 1.0%; iron, 0.5%.

C. Turkey Rations Using FDBM

Ingredient	Prestarter 0-2 wks	Starter 2-8 wks	Grower 8-16 wks	Finisher 16 wks-mkt.	Breeder
Flash dried blood meal	80	80	80	40	80
Ground shelled corn	845.5	927	1266	1506	1336
Dehulled soybean meal	800	700	400	200	200
Wheat middlings	0	0	0	0	100
Alfalfa meal (17%)	60	60	50	50	60
Meat and bone meal (50%)	50	50	60	50	50
Dried whey	50	40	0	0	50
Stabilized fat	20	60	80	100	0
Salt	5	8	8	8	7
Dicalcium phosphate	50	50	40	30	40
Calcium carbonate	20	20	10	10	70
Vitamins & trace minerals[a]	7.5	5	5	5	6
Antibiotic	10	0	0	0	0
DL-methionine	2	1	1	1	1
Coccidiostat & Blackhead preventative	+	+	+	+	-
	2000	2000	2000	2000	2000
Calculated Analyses					
ME, kcal/lb	1270	1325	1410	1500	1270
Crude protein, %	29.5	27.2	21.1	15.1	17.3
Fat, %	3.5	5.5	7.1	8.4	3.3
Fiber, %	2.9	2.8	2.6	2.5	2.7
Ca, %	1.41	1.40	1.09	0.87	2.20
Total,P %	0.98	0.95	0.82	0.68	0.80
Available P, %	0.73	0.71	0.62	0.49	0.60
Arginine, %	1.98	1.80	1.32	0.91	1.00
Isoleucine, %	1.35	1.20	0.90	0.68	0.71
Lysine, %	1.80	1.60	1.20	0.91	0.94
Methionine, %	0.54	0.46	0.39	0.31	0.33
Met & Cys, %	0.98	0.87	0.71	0.55	0.61
Tryptophan, %	0.35	0.32	0.23	0.15	0.18

[a]Containing per pound: vitamin A, 600,000 IU; vitamin D_3, 166,665 ICU; vitamin E, 500 IU; menadione sodium bisulfite, 134 mg; riboflavin, 400 mg; niacin, 3334 mg; pantothenic acid, 800 mg; choline chloride, 41 g; folic acid, 117 mg; vitamin B_{12}, 1 mg; thiamine mononitrate, 67 mg; manganese, 1.53%; iodine, 0.02%; copper, 0.16% cobalt, 0.005%; zinc, 1.0%; iron, 0.5%.

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