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Abstract

Two experiments were conducted to determine the apparent and true-ileal amino acid digestibility, and to determine the digestible energy and metabolizable energy values of rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, and spray-dried animal plasma. The experimental ingredients were analyzed for essential and non-essential amino acids and crude protein so diets could be formulated. In Exp.1, pigs were fed each diet, and ileal digesta was collected and analyzed. Apparent and true digestibilities were then calculated. In Exp. 2, pigs were fed each diet and feces were collected, weighed, and sampled. Lab analyses were conducted for the determination of gross energy (GE) and digestible energy (DE). Then ME values were determined by calculation from the DE and CP concentrations of experimental diets. In Exp. 1, TID lysine, methionine, and threonine values were 86.6, 69.0, and 78.9% for rice protein concentrate; 89.7, 88.7, and 80.2% for salmon protein hydrolysate; 95.7, 93.9, and 88.4% for whey protein concentrate; and 95.4, 93.5, and 92.2% for spray-dried animal plasma, respectively. In Exp. 2, DE values for rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, and spray-dried animal plasma were 2143, 1893, 2245, and 2062 kcal/lb, respectively. The ME values that were determined for the protein products were 1917, 1598, 1974, and 1805 kcal/lb, respectively.; Swine Day, 2004, Kansas State University, Manhattan, KS, 2004

Keywords

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DETERMINATION OF THE APPARENT AND TRUE ILEAL AMINO ACID DIGESTIBILITY AND DIGESTIBLE AND METABOLIZABLE ENERGY OF SPECIALTY PROTEIN SOURCES INTENDED FOR NURSERY PIG DIETS[1]

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Summary

Two experiments were conducted to determine the apparent and true-ileal amino acid digestibility, and to determine the digestible energy and metabolizable energy values of rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, and spray-dried animal plasma. The experimental ingredients were analyzed for essential and non-essential amino acids and crude protein so diets could be formulated. In Exp.1, pigs were fed each diet, and ileal digesta was collected and analyzed. Apparent and true digestibilities were then calculated. In Exp. 2, pigs were fed each diet and feces were collected, weighed, and sampled. Lab analyses were conducted for the determination of gross energy (GE) and digestible energy (DE). Then ME values were determined by calculation from the DE and CP concentrations of experimental diets. In Exp. 1, TID lysine, methionine, and threonine values were 86.6, 69.0, and 78.9% for rice protein concentrate; 89.7, 88.7, and 80.2% for salmon protein hydrolysate; 95.7, 93.9, and 88.4% for whey protein concentrate; and 95.4, 93.5, and 92.2% for spray-dried animal plasma, respectively. In Exp. 2, DE values for rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, and spray-dried animal plasma were 2143, 1893, 2245, and 2062 kcal/lb, respectively. The ME values that were determined for the protein products were 1917, 1598, 1974, and 1805 kcal/lb, respectively.

(Key Words: Digestibility, Pigs, Rice Protein Concentrate, Salmon Protein Hydrolysate, Whey Protein Concentrate, Spray-dried Animal Plasma.)

Introduction

The inclusion of high-quality protein ingredients in nursery-pig diets is a common practice among nutritionists across the world. As new protein products are developed, however, reliable and accurate digestibility and energy values must be determined so nutritionists have greater confidence in these products when using them in diets. Although new protein products may have greater amounts of protein and amino acids, the true digestibility of these amino acids needs to be established for proper diet formulation to ensure that the nutritional needs of the newly weaned pig are being met.

There are no currently published data for rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, or spray-dried animal plasma for true ileal amino acid

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digestibilities, and only spray-dried animal plasma has published apparent ileal amino acid digestibility values. Also, rice protein concentrate, salmon protein hydrolysate, and whey protein concentrate lack digestible and metabolizable energy values.

The objective of this experiment was to determine the apparent and true ileal amino acid digestibility, and determine digestible and metabolizable energy values for rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, and spray-dried animal plasma.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved protocols used in this experiment.

Experiment 1. Six barrows (initially 65 lb) were surgically fitted with simple T-cannulas approximately 15 cm anterior to the ileocecal valve. Pigs were housed in stainless-steel metabolism cages and were randomly allotted to one of four dietary treatments in a balanced crossover design. Diets were formulated to 12.5% protein by using analyzed nutrient compositions of the four experimental treatments (Table 1). The diets used in Exp.1 were based on corn starch and contained either rice protein concentrate, salmon protein hydrolysate meal, whey protein concentrate, or spray-dried animal plasma (Table 2). All diets contained 0.25% chromic oxide as an indigestible marker.

Each 7-d feeding period consisted of a 6-d acclimation period followed by 1 day (12h/d) of ileal digesta collection. Feed was divided into two equal meals and fed at 0600 and 1800 each day. Pigs were weighed each week, and feed allowance was calculated to maintain intakes of 2.5% of BW. Water was provided at a rate of 2:1 water:feed (wt:wt). The average weight of the pigs at the end of the experiment was 92 lb.

Ileal digesta was collected between 0600 and 1800 for one day during each period by attaching a latex balloon to the cannula. Digesta in the balloon was collected periodically and stored under refrigeration during the 12-h collection period. At the end of each day's collection, the digesta was frozen and stored. At the conclusion of collection for the experiment, digesta from each pig, in their respective periods, were homogenized and a 200-g subsample was taken. The samples were then freeze-dried and ground for analysis. All nutrient digestibilities were calculated by using chromic oxide as the indigestible marker.

Experiment 2. Six barrows (initially 82.9 lb) were used to determine DE and ME values for the four experimental ingredients. Pigs were housed in stainless-steel metabolism cages designed to allow separate collection of feces. Pigs were allotted to one of five dietary treatments in a balanced crossover design. The four experimental ingredients were from the same batches as those used in Exp. 1. Diets were formulated to contain approximately 20.0% CP, except for the corn control diet. Because the corn in each diet also supplied energy, a fifth diet was fed to determine the energy value of corn so the DE and ME of the experimental diets and protein products could be calculated by difference.

Feed was divided into two equal meals and fed at 0600 and 1800 each day. Pigs were weighed every week and feed allowance was calculated to maintain daily intakes of 3.0% of BW. Water was provided twice daily at a rate of 2:1 water:feed (wt:wt). The average weight of the pigs at the end of period 5 was 112.2 lb.

The five feeding periods consisted of 3 days of diet acclimation followed by 4 days of total fecal collection. Feces were collected twice daily and later pooled for each period. The feces then were mixed, dried, and ground, from which a representative subsample was taken. This subsample was ground once more and used for analysis. Ferric oxide (1% of

diet) was used as the indigestible marker to identify the beginning and end of each collection period. Feed and feces were analyzed for GE by using adiabatic bomb calorimetry.

The DE values of protein products were then calculated by subtracting gross energy excreted from gross energy intake. This value was then expressed as a percentage and multiplied by the GE value for the feed, and shown in kcal/lb (Table 5).

For ME values of each ingredient, the equation below was used, based on the DE and CP of diets containing each protein product. Individual ME values were then calculated by difference from the ME value determined from the corn used in the diets.

$$ME = DE \times (1.003 - (0.0021 \times \%CP))$$
$$R^2 = 0.48$$

Results and Discussion

Analyzed nutrient compositions of each protein product are reported in Table 1. Crude protein values ranged from a low of 67.51% for rice protein concentrate to a high of 92.70% for salmon protein hydrolysate.

Apparent-ileal-digestible (AID) lysine, methionine, and threonine values were 80.0, 65.6, and 68.4% for rice protein concentrate; 85.6, 85.5, and 69.8% for salmon protein hydrolysate; 93.3, 89.9, and 83.6% for whey protein concentrate; and 92.8, 85.7, 86.5% for spray-dried animal plasma, respectively.

The TID lysine, methionine, and threonine values were 86.6, 69.0, and 78.9% for rice protein concentrate; 89.7, 88.7, and 80.2% for salmon protein hydrolysate; 95.7, 93.9, and 88.4% for whey protein concentrate; and 95.4, 93.5, 92.2% for spray-dried animal plasma, respectively.

Digestible-energy values for rice protein concentrate, salmon protein hydrolysate, whey protein concentrate, and spray-dried animal plasma were 2143, 1893, 2245, and 2062 kcal/lb, respectively. Metabolizable energy values for the ingredients were 1917, 1598, 1974, 1805 kcal/lb, respectively.

Apparent and true amino acid digestibility values were established for specialty protein products for nursery pigs. Although amino acid digestibility values did differ, all protein products tested seem to have high amino acid utilization in swine diets. Although the use of spray-dried animal plasma and whey protein concentrate for nursery pigs has been researched, use of rice protein concentrate and salmon protein hydrolysate has not. Further research to determine growth performance of nursery pigs fed these protein products is needed for practical application by nutritionists.

Table 1. Analyzed Nutrient Composition of Ingredients (As-fed Basis)

Nutrient	Rice Protein Concentrate	Salmon Protein Hydrolysate	Whey Protein Concentrate	Spray-dried Animal Plasma
DM, %	92.68	91.44	94.69	90.85
CP, %	67.51	92.70	80.18	77.95
Ash, %	3.41	6.84	2.46	8.60
Amino Acids, %:				
Arginine	5.26	5.47	2.03	4.57
Histidine	1.65	1.59	1.56	2.61
Isoleucine	2.91	2.16	5.15	2.90
Leucine	5.31	3.97	8.69	7.51
Lysine	2.21	5.05	7.49	6.90
Methionine	1.77	1.89	1.64	0.69
Phenylalanine	3.52	2.10	2.65	4.38
Threonine	2.12	2.62	5.01	4.33
Tryptophan	0.81	0.48	1.61	1.38
Valine	4.13	2.78	4.82	5.20
Alanine	3.47	5.93	3.81	4.18
Aspartic acid	5.39	6.18	8.21	7.35
Cysteine	1.45	0.42	1.83	2.73
Glutamic acid	10.87	10.01	13.80	11.53
Glycine	2.77	11.99	1.44	2.76
Proline	2.94	6.17	4.92	4.44
Serine	2.36	2.60	2.96	3.98
Tyrosine	3.32	1.32	2.38	4.04

Table 2. Diet Composition (Exp. 1; As-fed Basis)

Ingredient, %	Protein Free	Rice Protein Concentrate	Salmon Protein Hydrolysate	Whey Protein Concentrate	Spray-dried Animal Plasma
Corn starch	80.80	74.12	79.59	70.46	70.95
Rice protein concentrate	---	18.55	---	---	---
Salmon protein hydrolysate	---	---	13.48	---	---
Whey protein concentrate	---	---	---	16.60	---
Spray dried animal plasma	---	---	---	---	16.45
Sucrose	10.00	---	---	---	---
Solca floc	3.00	---	---	6.00	6.00
Soy oil	3.00	3.00	3.00	3.00	3.00
Monocalcium phosphate, 21% P	1.45	2.85	2.20	2.55	1.55
Limestone	0.30	0.48	0.75	0.38	1.05
Salt	0.40	0.35	0.35	0.35	0.35
Vitamin premix	0.05	0.25	0.25	0.25	0.25
Trace mineral premix	0.25	0.15	0.15	0.15	0.15
Potassium chloride	0.40	---	---	---	---
Magnesium chloride	0.10	---	---	---	---
Chromic oxide	0.25	0.25	0.25	0.25	0.25
TOTAL	100.00	100.00	100.00	100.00	100.00
Calculated Analysis[a]					
Total lysine, %	0.01	0.41	0.68	1.25	1.14
CP, %	0.06	12.50	12.50	12.50	12.50
Ca, %	0.38	0.71	0.71	0.72	0.71
P, %	0.31	0.60	0.60	0.60	0.61
Available P, %	0.31	0.60	0.53	0.59	0.58

[a]Based on analyzed values reported in Table 1.

Table 3. Diet Composition (Exp. 2; As-fed Basis)

Ingredient, %	Rice Protein Concentrate	Salmon Protein Hydrolysate	Whey Protein Concentrate	Spray-dried Animal Plasma	Corn Control[a]
Corn	75.97	82.51	78.82	79.42	96.18
Rice protein concentrate	20.05	---	---	---	---
Salmon protein hydrolysate	---	13.98	---	---	---
Whey protein concentrate	---	---	17.70	---	---
Spray-dried animal plasma	---	---	---	17.45	---
Monocalcium phosphate, 21% P	2.10	1.30	1.73	0.60	1.80
Limestone	0.90	1.23	0.78	1.55	1.03
Salt	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15
Chromic oxide	0.25	0.25	0.25	0.25	0.25
TOTAL	100.00	100.00	100.00	100.00	100.00
Calculated Analysis[b]					
Total lysine, %	0.64	0.92	1.53	1.41	0.00
CP, %	20.00	20.00	20.90	20.30	8.20
Ca, %	0.75	0.75	0.75	0.75	0.75
P, %	0.65	0.65	0.65	0.65	0.65
Available P, %	0.47	0.38	0.46	0.43	0.42

[a]The corn diet was used to determine the energy value of corn, so energy values of the test protein products could be determined by difference.
[b]Based on analyzed values reported in Table 1.

Table 4. Apparent and True-ileal Digestibility of Ingredients (Exp. 1)[a]

	Rice Protein Concentrate		Salmon Protein Hydrolysate		Whey Protein Concentrate		Spray-dried Animal Plasma	
Amino Acids	AID, %[b]	TID, %[c]	AID, %	TID, %	AID, %	TID, %	AID, %	TID, %
Arginine	86.8	89.9	90.6	94.6	86.0	94.5	92.7	96.8
Histidine	80.0	82.9	78.5	81.8	88.0	90.9	91.8	93.5
Isoleucine	75.6	80.7	72.2	81.2	90.8	94.3	87.1	92.8
Leucine	75.5	79.3	76.1	82.9	92.3	95.2	90.6	93.7
Lysine	80.0	86.6	85.6	89.7	93.3	95.7	92.8	95.4
Methionine	65.6	69.0	85.5	88.7	89.9	93.9	85.7	93.5
Phenylalanine	77.4	80.5	73.2	80.4	84.7	90.0	89.4	92.5
Threonine	68.4	78.9	69.8	80.2	83.6	88.4	86.5	92.2
Tryptophan	84.7	103.9	65.4	104.8	92.3	102.2	91.2	101.0
Valine	76.0	81.3	73.7	83.4	87.4	92.5	89.2	93.8
Alanine	74.0	79.5	84.5	88.8	85.2	91.4	87.6	93.3
Aspartic acid	77.2	81.2	66.1	68.5	89.9	93.1	87.9	91.4
Cysteine	64.7	63.5	38.2	33.9	86.4	84.8	91.0	90.0
Glutamic acid	72.8	74.6	83.3	86.3	90.2	92.1	90.3	92.7
Glycine	72.7	84.6	84.2	87.9	52.6	76.0	74.6	87.8
Proline	69.5	77.8	81.4	86.6	83.9	89.9	87.8	93.7
Serine	73.3	79.7	79.5	86.6	84.7	89.8	88.7	93.5
Tyrosine	72.3	76.9	62.7	73.9	80.6	86.0	90.7	93.9

[a]Values are the means of six pigs (initially 65 lb) used in a balanced crossover design.
[b]Apparent ileal digestibility.
[c]True ileal digestibility.

Table 5. Diet Energy Density (Exp. 2; As-fed Basis)

Ingredient, %	Rice Protein Concentrate	Salmon Protein Hydrolysate	Whey Protein Concentrate	Spray-dried Animal Plasma	Corn
Gross energy, kcal/lb	2247	2181	2379	2099	1841
Digestibility energy, kcal/lb	2143	1893	2245	2062	1511
Metabolizable energy, kcal/lb	1917	1598	1974	1805	1489

[a]The corn diet was used to determine the energy value of corn, so energy values of the test protein products could be determined by difference.