The Bioavailability of Nutrients in Some Philippine Feedstuffs to Poultry

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Introduction

In the Philippines, feeds account for most of the production cost of poultry and swine due to shortage of energy and protein sources. Local grain production does not meet the total demand for animal feeds, and likewise only the excess of human consumption of root crops goes to feed. Practically, almost all protein feeds, trace minerals and vitamines are imported. Only the by-product feeds are produced locally and are available in commercial volume. But these feedstuffs are bulky, generally low in energy and protein, high in fiber, and poor in amino acids balance.

Thus, without the imported cereal grains and protein sources, by-product feeds can not serve a good balanced diet for poultry and swine. In order to formulate a good balanced diet, it is desirable to know the availability of the nutrients in the feedstuffs.

Nevertheless, there is little information on the nutrient composition as well as the availability of the nutrients in the feed ingredients which are commonly used in the feed formulation of poultry and swine rations.

The objective of this study is to determine the bioavailability of the nutrients in some Philippines feedstuffs to poultry.

Materials and procedures

1) *Feedstuffs*

Fourteen feed samples were used in this study (Table 1). White corn makes up the big bulk of the total corn production in the country because it is the staple food of farmers in the rural areas in the southern part of the country. Rice bran is a by-product in the milling of rice, available in three classes (D1, D2, D3). The three classes differ in the amounts of rice hulls in the product which depends on the type and efficiency of the rice mill in separating the hull during milling. Many times, the rice hull is also added as an adulterant in rice bran, so that its quality varies tremendously. Coconut oil meal, or more popularly known as copra meal, is the residue after the extraction of oil from dehydrated coconut meat. The amount of residual oil in the meal depends on the method of extraction used. Copra meal is available in the form of meal cake and pellet.

Table 1. List of selected feedstuffs and potential feed substitutes submitted to chemical analyses and bioassay

Conventional feedstuffs:
Yellow corn (YC)-USA
-China
White corn (WC)-Philippines
Soybean oil meal (SOM)-China
Rice bran D-1, first class (RB-D1)
〃 D-2, second class (RB-D2)
Coconut oil meal (COM) cake
Pellet
Wheat pollard (WP)
Ipil-ipil (*Leucaena leucocephla*) leaf meal (ILM)
Potential feed substitutes:
Cassava (*Manihot esculenta*) leaf meal (CLM)
Mung bean (*Phaseolus mungo, aureous*) (MB)
Pigeon pea (*Cajanus cajan*) (PP)
Rice bean (*Phaseolus calcaratus*) (RB)

Wheat pollard is a combined by-product in the milling of wheat into flour. It contains the bran and a part of the endosperm.

Mung bean, pigeon pea and rice bean are legume seeds which are primarily grown for human consumption. Since these are tropical crops, they have the potential as substitutes for a part or a whole of soybean oil meal in the diet of poultry or swine, if their use can be proven economically feasible. Ipil-ipil leaf meal is a traditional feed added at 3 to 5% of the diet to provide the desirable pigmentation in the egg yolk and skin of broilers. But, at present this leaf meal completely disappears from the market due to heavy infestation of the ipil-ipil trees with "jumping Lice". Cassava leaf meal if found to be nutritionally acceptable may prove to be a potential substitute for ipil-ipil leaf meal.

2) Chemical analyses

The feed samples were analyzed for complete proximate analysis (moisture, crude protein, crude fiber, ether extract and ash), gross energy and amino acids. The procedures for proximate analysis followed the Association of Official Analytical Chemist[1]. Gross energy was measured using the Parr adiabatic bomb calorimeter, and nitrogen using the Technicon Block Digestor and Auto-analyser, model A 11.

For amino acid analysis except for tryptophan, methionine and cystine, samples were hydrolyzed with 6*N* HCl at 110°C for 24 hr. Analysis of the amino acid from the hydrolysates was done using the automatic amino acid analyser (Hitachi model 835). Cystine and methionine were determined as cysteic acid and methionine sulfone by the method of Moore[4]. For tryptophan, samples were hydrolyzed with $Ba(OH)_2$ at 110°C for 15 hr. The tryptophan contents of the hydrolysates were determined by the high performance liquid chromatography (Jasco Trirotor III).

3) Metabolism trials

Three sets of metabolism trials were completed during this study; in each trial, 20 one-year-old roosters (White Leghorn) and five feed samples were used. Before each trial, the roosters were individually weighed and randomly distributed to five dietary treatments of four roosters per feed sample such that the average weight of the four roosters was the same for all five treatments. The birds used for trials were fasted to determine metabolic fecal and endogenous urinary losses of energy and amino acids. Procedures in determining TME, TME_n and true amino acid availability followed the TME system developed by Sibbald[6] and Likuski & Dorrell[3]. The roosters were fasted for about 40 hr, then each feedstuff (30 g for cereal and legume grains and 25 g for the by-product feeds and leaf meals) was force-fed into each rooster using a stainless long stem funnel. Excreta were collected quantitatively for each rooster with the final collection completed at exactly 48 hr after force feeding. Excreta were cleaned from feathers and scales. Fecal samples from each rooster were combined, freeze dried and then allowed to equilibrate with atmospheric humidity before weighing and grinding with mortar and pestle for chemical analysis. Each excreta sample was analyzed separately.

Results and discussion

1) Chemical composition

Variations in the proximate composition of the 14 feedstuffs are given in Table 2. The two classes of rice bran (D1 and D2) differ slightly in CP but a larger difference lies in CF and EE. Likewise there is a marked difference in the EE of the two forms of coconut oil meal. Perhaps low fat coconut oil meal is used for the pellet to produce better quality pellet and to prevent rancidity during storage since the pellet form is intended for export. The legume seeds are very low in fat but high in soluble carbohydrate, while their CP content is not high enough as a protein substitute. Cassava leaf meal based from its proximate composition shows to be a potential substitute for ipil-ipil leaf meal.

2) Energy value

The metabolizable energy values of the 14 feedstuffs are given in Table 3. There seems to be no difference in the energy values of the two yellow corn samples imported from USA and China. But white corn is 200 kcal/kg lower than yellow corn, although their proximate composition are essentially the same except for a very slight difference in EE. There is about 500 kcal/kg difference between the two classes of rice bran, and about 650 kcal/kg difference between two forms of coconut oil meal. This difference may be explained by the lower fat and higher fiber in rice bran D2 and lower fat in the coconut oil meal pellet.

Table 2. Proximate composition of some selected feedstuffs and potential feed substitutes in the Philippines (% as fed)

Feedstuff*	DM	CP	EE	CF	NFE	Ash
YC-USA	87.0	8.3	3.8	2.4	71.3	1.2
-China	86.6	8.3	4.2	2.1	70.8	1.2
WC-Phil	85.8	8.3	3.7	2.2	70.1	1.5
RB-D1	86.1	12.5	16.0	6.1	43.3	8.2
-D2	88.1	10.8	12.8	11.2	41.5	11.8
COM-cake	92.4	19.2	12.2	11.5	44.1	5.4
-pellet	89.2	20.9	4.9	10.2	47.0	6.2
WP	86.7	16.7	4.5	7.4	53.4	4.7
SOM-China	88.0	42.3	5.6	4.5	30.3	5.3
MB	88.8	23.7	0.7	4.1	57.1	3.2
PP	86.3	24.0	0.8	8.2	49.0	4.3
RB	85.2	17.7	0.6	6.8	56.2	3.9
ILM	88.5	22.8	6.8	12.7	39.0	7.2
CLM	86.5	30.4	7.6	9.8	32.4	6.3

DM: dry matter, CP: crude protein, EE: ether extract, CF: crude fiber, NFE: nitrogen free extract.
* See Table 1.

Table 3. The metabolizable energy values of some feedstuffs and potential feed substitutes in the Philippines (kcal/kg as fed)

Feedstuff*	GE(a)	TME	TME_n(b)	(b/a)
YC-USA	3970	3570	3450	86.9
-China	3970	3650	3500	88.2
WC-Phil	3890	3410	3280	84.3
RB-D1	4410	3070	2970	67.3
-D2	4240	2610	2490	58.7
COM-cake	4610	2560	2350	51.0
-pellet	4090	1850	1710	41.8
WP	4040	2260	2050	50.7
SOM-China	4410	2680	2380	54.0
MB	4030	3000	2830	70.2
PP	3820	2180	1980	51.8
RB	3750	1770	1570	41.9
ILM	4460	360	280	6.3
CLM	4620	1530	1460	31.6

GE: gross energy, TME: true metabolizable energy, TME_n: true metabolizable energy corrected to zero nitrogen balance.
* See Table 1.

Among the three legumes, only mung bean exceeded the energy value of soybean oil meal. The low energy values of pigeon pea and rice bean may be explained by its high CF content and possibly some anti-nutritional factors associated with legume seeds. The TME_n of cassava leaf meal is higher than ipil-ipil leaf meal, which further suggests that it is a good feed substitute for ipil-ipil leaf meal.

3) Amino acid value

There are no differences in amino acid composition between a white corn and two yellow corn samples. However, the white corn has lower percent true amino acid availability (TAAA) than two yellow corn samples. Marked differences are particularly observed in isoleucine, threonine, tryptophan and valine. Thus, when one considers the available amino acids in white corn, they are slightly lower than in yellow corn. The two yellow corn samples from USA and China are about the same in available amino acids. Rice bran D2 is lower in the amino acids and percent TAAA than D1. As much as 5 to 10% difference was obtained in several amino acids. On the average, TAAA for the amino acids is about 78 and 72% for D1 and D2, respectively. The lowest values were obtained for threonine and serine in both D1 and D2. On the other hand, there is only a slight difference in the amino acids between the two forms of coconut oil meal. Although there is no clear pattern in their percent TAAA common to both forms, the pellet has higher TAAA values for most of the amino acids except for lysine. Pelleting significantly decreased the true availability of lysine from about 49% in cake to 36%. Unlike in rice bran, there is a wide variability in percent TAAA among the 17 amino acids. Wheat pollard has higher percent TAAA for histidine, lysine, and threonine but lower in methionine than the coconut oil meal products and rice bran D2. These data on by-product feeds seem to be different from the data currently used for these products in the Philippines[5]. There are actually no accurate values on amino acids to distinguish D1 from D2 or the cake from the meal. Similarly, the amino acid values for wheat bran are used for wheat pollard, while the data from this study show that on the standpoint of nutrition, wheat pollard is a superior product than wheat bran.

The sample of soybean oil meal used in this study is imported from China and it was found to be high in urease activity. The high urease activity suggests that the product is undercook and it contains some residual anti-nutritional factors associated with raw soybean[7]. Most of the soybean oil meal supplies in the Philippines come from China because of its lower price compared to other

Table 4. Amino acid composition, mg/g (A), and percent true amino acid availability (B) in feedstuffs (as fed)

AA		YC* USA	YC China	WC Phil	RB D1	RB D2	COM cake	COM pellet
Arg	A	4.0	4.0	4.2	11.1	8.5	23.9	23.4
	B	90.5	92.3	88.8	85.3	83.6	83.4	82.1
Cys	A	1.8	1.8	1.8	3.1	3.2	3.6	3.5
	B	87.9	88.0	86.3	75.3	73.4	61.3	62.7
His	A	2.2	2.4	2.3	3.7	2.9	4.0	4.1
	B	96.9	97.0	94.6	80.3	75.6	74.7	74.6
Ile	A	2.7	2.8	2.8	4.4	3.6	5.3	6.7
	B	90.2	91.5	84.6	75.4	71.3	69.5	80.0
Leu	A	10.4	10.5	10.5	9.4	7.5	12.9	13.7
	B	95.2	95.5	92.7	76.7	72.5	78.8	82.2
Lys	A	2.5	2.5	2.7	6.2	5.1	5.8	5.3
	B	82.9	87.8	82.4	74.9	67.6	49.3	36.3
Met	A	2.0	2.0	1.9	2.9	2.8	3.2	3.0
	B	92.8	92.5	89.5	79.6	78.5	83.5	85.5
Phe	A	4.2	4.1	4.0	5.7	4.7	8.6	9.1
	B	93.3	93.9	90.0	76.0	72.6	82.6	84.9
Thr	A	3.4	3.2	3.4	5.5	4.5	7.2	7.3
	B	85.7	86.8	79.7	72.2	62.9	67.6	69.1
Try	A	0.6	0.6	0.4	1.6	1.4	2.0	2.0
	B	88.0	88.0	77.7	76.0	68.7	50.0	52.1
Val	A	3.7	3.9	3.9	6.9	5.6	9.5	10.1
	B	88.6	91.6	83.9	77.3	71.0	77.2	81.8
Ala	A	6.4	6.3	6.9	8.2	6.7	8.6	8.9
	B	97.5	98.5	94.5	79.2	73.6	75.1	78.2
Asp	A	4.9	5.1	5.5	10.6	8.7	15.0	15.8
	B	95.1	97.5	90.5	78.1	71.8	75.6	79.3
Glu	A	15.6	15.6	17.2	18.3	14.7	37.7	40.1
	B	98.3	99.1	95.5	83.5	79.7	81.0	82.9
Pro	A	7.7	7.5	7.7	6.0	4.6	6.9	6.7
	B	95.9	98.3	94.9	77.8	67.3	77.7	80.7
Ser	A	4.1	4.0	4.6	6.3	5.1	9.2	9.6
	B	86.3	87.4	83.5	71.7	63.5	73.7	73.6
Tyr	A	3.0	3.2	3.6	4.7	3.6	5.4	5.6
	B	97.0	95.9	93.4	80.4	77.0	76.1	79.6

Each value is an average of four roosters.
* See Table 1.

sources. The data on percent TAAA of the sample of soybean oil meal in this study showed lower values than the values obtained in the previous study[7] using soybean oil meal of acceptable quality.

Among the legume seeds, mung bean has the highest availability of amino acid, while rice bean has the lowest. At this point, rice bean can be removed from the lists of potential feed substitutes because of its poor availability in energy and amino acids. Mung bean has a good potential while pigeon pea deserves further consideration. It may be worth mentioning here, that the percent TAAA is higher for almost all of the amino acids in mung bean than in soybean oil meal, while pigeon pea is comparable in most of the amino acids with soybean oil meal.

This study suggests that ipil-ipil leaf meal is too fibrous for the utilization for poultry. The data show an extremely low amino acid availability particularly for methionine, in spite that it contains a considerable amount of CP (23%). In all aspects of feed evalua-

Table 5. Amino acid composition, mg/g (A), and percent true amino acid availability (B) in feedstuffs (as fed)

AA		WP*	SOM China	MB	PP	RB	ILM	CLM
Arg	A	12.7	33.1	17.9	12.8	12.3	12.5	17.4
	B	80.4	85.7	86.8	81.7	71.9	36.5	77.3
Cys	A	3.2	5.9	1.8	3.0	2.1	2.8	3.8
	B	73.7	61.1	63.8	65.5	50.1	5.0	52.2
His	A	4.6	10.9	6.7	7.5	5.3	4.4	6.1
	B	81.7	81.6	83.3	80.9	66.4	19.6	66.8
Ile	A	5.1	18.3	10.2	7.5	7.7	8.7	13.5
	B	75.1	78.3	84.1	77.5	65.4	29.8	75.7
Leu	A	10.6	32.5	19.0	14.8	14.2	16.1	26.3
	B	79.9	79.1	85.1	78.2	65.9	23.7	75.6
Lys	A	7.0	24.1	17.3	13.5	13.5	12.1	16.5
	B	70.7	77.0	82.6	78.0	69.3	23.4	66.7
Met	A	2.5	6.2	3.3	2.9	2.7	3.7	6.0
	B	72.4	74.6	79.0	72.7	62.6	12.1	75.1
Phe	A	7.0	21.8	14.2	18.4	10.9	10.6	16.5
	B	82.4	81.4	85.9	86.3	68.5	35.4	75.1
Thr	A	6.0	17.6	8.7	7.8	7.2	9.3	14.6
	B	70.4	76.2	79.8	72.4	63.5	23.0	71.8
Try	A	2.3	5.6	2.8	1.4	1.7	4.1	5.9
	B	78.2	72.1	75.6	70.3	54.5	18.8	70.1
Val	A	7.4	18.8	12.2	8.9	9.2	10.9	17.0
	B	76.3	76.7	84.3	75.2	66.1	27.8	76.8
Ala	A	8.2	18.1	10.4	8.7	8.1	11.0	19.6
	B	76.4	76.3	82.5	73.7	64.7	25.7	77.0
Asp	A	11.1	44.0	25.3	18.3	19.2	21.4	25.8
	B	77.0	81.0	84.9	78.6	68.5	44.4	76.7
Glu	A	33.9	76.2	41.9	38.2	29.5	21.0	33.0
	B	88.7	85.5	87.5	84.1	71.0	26.7	77.2
Pro	A	10.8	21.5	9.9	8.3	8.3	10.5	16.7
	B	88.3	82.0	85.7	76.1	68.6	30.6	74.6
Ser	A	7.8	22.9	12.8	10.1	9.5	9.3	13.3
	B	75.6	78.6	83.9	73.5	64.9	18.9	71.1
Tyr	A	5.6	17.1	8.2	6.3	6.3	8.1	12.4
	B	81.5	86.5	82.7	76.0	67.2	23.8	76.2

Each value is an average of four roosters.
* See Table 1.

tion, cassava leaf meal has shown to be superior in quality than ipil-ipil leaf meal. Cassava leaves are abundant in the Philippines which can be processed into leaf meals but it has never been tapped to substitute ipil-ipil leaf meal because of lack of information on its nutritional values. Fresh cassava leaves contain prussic acid which is toxic but unstable which is usually destroyed during the drying process. Further verification to quantify the residual prussic acid in the leaf meal may be needed.

Summary

True metabolizable energy and true amino acid availability were determined by the method of Sibbald with adult roosters in order to evaluate the nutritive values in some Philippines feedstuffs (corn, rice bran, coconut oil meal, legume seeds and leaf meal) to poultry and the following results were obtained.

True metabolizable energy values of by-product feeds were largely affected by crude fat and crude fiber contents. Among the three legumes, mung bean was the highest in the nutritive value, while rice bean was the lowest. The nutritive value of cassava leaf meal was higher than ipil-ipil leaf meal, suggesting that it is a good feed substitute for the ipil-ipil leaf meal.

References

1) Association of Official Analytical Chemists: Official methods of analyses. 12th ed. Washington D.C. (1975).
2) Balloun, L. S.: Soybean meal in poultry nutrition. American Soybean Association, St. Louis, Mo. 29 (1980).
3) Likuski, H. J. H. & Dorrell, H. G.: A bioassay for rapid determination of amino acid availability values. *Poultry Sci.*, 57, 1658–1660 (1978).
4) Moore, S.: On the determination of cystine as cysteic acid. *J. Biol. Chem.*, 238, 235–237 (1963).
5) Philippine Council for Agriculture and Resources, Research and Development: Feed composition table for the Philippines 1984. Philippine National Feed Information Center, University of the Philippines at Los Baños (1984).
6) Sibbald, I. R.: The TME system of feed evaluation methodology, feed composition data and bibliography. Tech. Bull. 1986-4E. An. Res. Center, Ottawa, Ontario, Canada (1986).
7) Yamazaki, M. & Kamata, H.: Amino acid availability of feed ingredients for poultry. *Jpn. Poultry Sci.*, 23, 147–156 (1986) [In Japanese with English summary].

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