AMINO ACID DIGESTIBILITIES OF PALM KERNEL MEAL IN POULTRY

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Received February 12, 2008; Accepted April 02, 2008

ABSTRACT

Palm kernel meal (PKM) is produced in large quantities in many parts of the world. Problems associated with PKM are due to their high fibre content, imbalanced amino acid ratios, the possibility of Maillard products and their own physical characteristics (high bulk density and low water holding capacity). This study was conducted to determine the nutrient digestibility, jejunal digesta viscosity, apparent metabolizable energy and physical characteristics of PKM. A total of 28 day old male Ross chicks were given control starter and grower diets from day 1 to 35. From day 36, the birds were fed an experimental diet which contained 91.5% PKM plus sunflower oil, vitamins and minerals. Faeces were collected for three consecutive days. Jejunal digesta was measured for viscosity and ileal digesta was used for amino acid digestibility measurements. Data indicated that bulk density and water holding capacity of PKM were very close to the values of bulk density and water holding capacity of most conventional feedstuffs. Nutritionally, PKM contained low crude protein and high crude fibre. Dry matter, crude protein, neutral detergent fibre and amino acid digestibilites were low, but arginine digestibility was quite high, being about 82%. Jejunal digesta viscosity was low (1.54 cP) and apparent metabolizable energy was moderate, being 9.45 MJ/kg.

Keywords: Palm Kernel Meal, Nutritive Values, Physical Characteristics

ABSTRAK

Bungkil kelapa sawit diproduksi secara besar – besaran di beberapa kawasan didunia. Pemanfaatan bungkil kelapa sawit untuk pakan ternak memiliki banyak persoalan seperti: kandungan serat yang tinggi, ketidakseimbangan asam amino, kemungkinan adanya produk maillard masalah karakter fisik berupa bulk densitas dan kemampuan mengikat air yang rendah. Penelitian ini dilaksanakan untuk menentukan kecernaan nutrisi, viskositas digesta di jejunum, energi metabolisme semu karakter fisik dari bungkil kelapa sawit. Dua puluh delapan ekor ayam strain Ross umur satu hari diberi makan dengan ransom control starter dan grower dari hari 1 sampai 35. Dari hari 36, ayam diberi pakan eksperiment yang terdiri dari 91,5% bungkil kelapa sawit plus minyak bunga matahari, vitamin dan mineral. Viskositas digesta dari jejenum dan kecernaan asam amino di ileum duodenum dilakukan. Data menggambarkan bahwa bulk densitas dan kemampuan mengikat air dari bungkil kelapa sawit hamper sama dengan bulk densitas dan kemampuan mengikat air dari bahan pakan konvesnsional. Secara nutrisi, bungkil kelapa sawit mengandung protein yang rendah dan serah kasar yang tinggi. Kecernaan bahan kering, protein kasar, neutral detergent fibre dan asam amino adalah sangat rendah, tetapi kecernaan arginine sangat tinggi sekitar 82%. Viskositas digesta di jejenum sekitar 1.54 cP dan metabolisme energi semu adalah 9.45 MJ/kg.

Kata kunci: Bungkil Kelapa Sawit, Nilai Nutrisi, Karakteristik Fisik.

INTRODUCTION

Palm kernel meal (PKM) is available in large quantity in many tropical countries, particularly in Indonesia. About 70% of world's PKM production was supplied by Malaysia and Indonesia (FAO, 2002). Indonesia produced 0.96 million ton of PKM in 2002 and Indonesia's PKM production has increased by about 72% per year over the last two decades (FAO, 2002). Despite the fact that Indonesia produced large amount of PKM, this feedstuff is not widely used either for animal production or other purposes in Indonesia.

There is no data on the quantity of this feedstuff used in the livestock production sector. Of the total PKM production in Indonesia, 0.82 million ton were exported, equivalent to 85% (FAO, 2002). Therefore, this feedstuff is potential to be used for animal production in Indonesia or otherwise is thrown away as a concequence of their susceptibility to mold attack.

The digestibility of the nutrients and physical characteristics of feedstuffs are criteria for judging the quality of a feedstuff. Digestible energy is not widely used in poultry because of the difficulty of separating urine and faeces. Metabolisable energy (ME) is used instead due to its practicality. Methods applied for determining ME and amino acid (AA) digestibility have been reviewed by Sibbald (1989) and Ravindran and Bryden (1999) respectively. The collection of faeces for several days to measure metabolisable energy and the collection of ileal digesta to measure ileal digestibility are widely used techniques. Kyriazakis and Emmans (1995) stated that bulk density and water holding capacity (WHC) are two physical characteristics that could affect the nutritional value of the feed. These two characteristics have a negative correlation with feed intake.

Formulation of diets based on the ME and total AA compositions of feedstuffs (see NRC, 1994) have been practiced for a long time. The drawback of this method is that because the nutrients in the diets are not totally digested, digestibility depends a lot upon the ingredients included. The digestibility of its nutrients has therefore become a criterion for judging the quality of a feedstuff. Because the estimation of the nutrient requirements of chickens has been based on maize and soybean based diets, which have highly digested nutrients (Waldroup, 2000), formulation of diets containing less digestible feedstuffs needs to be based on digestible nutrients, particularly digestible AAs (Ravindran and Bryden, 1999). However, applying this method could take more time because of incomplete data about the AA digestibility of all ingredients and because of the variability of data as a result of the different methods used in its analysis. Data on the AAs digestibility of palm kernel meal (PKM), particularly ileal digestibility, was not recorded in the NRC (1994) data base.

This experiment therefore aimed to investigate the ileal digestibility of the AAs of PKM and its AME as well as its bulk density and water holding capacity.

MATERIALS AND METHODS

Animal and feed

A total of 28 day old male Ross chicks were used as experimental animals and were placed in brooder cages from days 1 to 17 and fed a control diet. On day 18, the birds were transferred into four replicates of 7 birds per cage and fed a control diet up to day 21. From day 21 to 35, the birds were given grower diets based mainly upon corn-soy (CS). From day 36, the birds were fed the experimental diet (Table 1). The diet was formulated by using UFFF software and mixed by using a cement mixer. The diet was offered twice a day, namely at 09.00 and 16.00 hours. During this trial, the animals were fed ad libitum and fresh water was available at all times. Cleaning of water troughs was done every three days to maintain the cleanliness of the water.

Representative feed samples were collected to determine dry matter (DM), nitrogen (N), AAs and neutral detergent fibre (NDF). Total faeces was collected daily on three consecutive days (days 40 to 42) and placed into plastic bags. Total faeces was weighed after discarding any foreign material, such as feathers and feed. About 20% of the faeces was then stored in the freezer as a sample. On day 42, four birds from each of the four replicate cages were randomly taken and then killed by cervical dislocation. The ileal digesta content from Meckel's diverticulum to 1 cm before the caeca was collected and then stored in a freezer.

Chemical analysis

Frozen faeces and feed samples were dried at 60^{o}C to measure the DM content. The frozen ileal digesta samples were freeze dried for measurement of AA and crude protein (CP) content. Prior to chemical analysis, feed, faeces and ileal digesta were ground using a 0.5 mm screen. Crude fibre (CF), lipid and ash were determined in dry samples according to AOAC (1990) methods. For NDF analysis, samples were defatted prior to analysis as recommended by Prosky et al. (1984). All analyses were performed in duplicate. Acid insoluble ash (AIA) was analysed by a method based on Siriwan et al. (1993). One g of digesta and 2 g of feed were dried, ashed (480^{o}C for 8 hours) and then boiled with 4 mol/L HCl for 1 hour. The residue was washed with HCl and deionized

Table 1. Experimental Diet (g/kg)

Ingredients	Composition
Palm Kernel meal	915
Sunflower oil	40
Limestone	16
Salt	5
Vitamin and Mineral mix	4
Celite	20

water and dried in an oven at 105°C overnight. The residue was weighed as AIA. The faecal digestibility of the diet and nutrients was calculated by the formula:

Apparent Digestibility of nutrients = [(Nutrients/AIA)d – (Nutrients/AIA)f / (Nutrients/AIA)d] X 100%

Where (Nutrients/AIA)d is the ratio of nutrients to acid insoluble ash in the diet and (Nutrients/AIA)f is the ratio of nutrients to acid insoluble ash in the faeces.

Analysis of viscosity was based on the method of Perez-Maldanado *et al.* (1999). Ileal digesta was centrifuged at 1459 X G for 15 minutes at 22 – 25°C. 0.5 ml of supernatant was taken for analysis using a Brookfield LVTCP model viscometer with CP-40 cone and expressed in centipoise (cP).

AA analysis was done by hydrolysis, evaporation and HPLC analysis. Samples were ground to pass through a 0.5 mm screen and weighed to contain approximately 80 mg CP. Ten ml of 8N HCl (6 g phenol in 400 ml ultra purified water and 1600 ml 32% HCl with specific gravity of 1.16) was added. The sample was then sonicated using an ultrasonic sonicator (FX-10, Unisonics Pty Ltd., Sydney, NSW) for 15 minutes and degassed by using a water suction pump for 5 minutes with care to avoid frothing. Another 30 ml of 8N HCl solution was added and flushed with N and quickly capped. Samples were hydrolysed by autoclaving at 120°C and 16 psi for 16 hours. Ultra-purified water was added to the sample in a 100 ml volumetric flask to make the hydrolysate up to 100 ml. The contents were mixed thoroughly after being cooled at 4°C and the volume adjusted.

To remove oxygen, an aliquot of the hydrolysate containing 8 mg CP and 1 ml of 4 mM DL-norleucine (as internal standard) were placed in a round bottom flask and then flushed with N and sealed with a glass stopper. A "Buchii" rotary evaporator under reduced pressure in a 65°C water bath was used to evaporate water and HCl. The evaporated samples were immediately dissolved with 8 ml 0.2N sodium citrate diluent and transferred to a 20 ml glass vial with Teflon lined caps and the pH was adjusted to 2.20. An equal volume of chloroform to remove fat was added and the top layer was collected in a syringe and filtered through a 0.22 µm pore nylon filter membrane (Alltech, Baulkam Hills, NSW) into injection vials. The samples were then analysed with a Shimadzu LC-10A analyser (Shim-Pack®, Shimadzu Co, Kyoto Japan)

The AME of the diet and AME of the PKM were calculated by the formula below. The AME of sunflower oil was based on the value reported by Novus (1992).

AME_{diet} = {(Food intake X GE_{diet}) – (Excreta output X $GE_{excreta}$)}/ Food intake

AME_{PKM} = {AME diet – $AME_{sunflower\ oil}$ X sunflower level)} / PKM level

RESULTS AND DISCUSSION

Results

The results of the proximate analysis and AA analysis are shown in Tables 2 and 3 respectively, while data of the physical characteristics of the feeds can be seen in Table 4. The digestibility of PKM DM, NDF and AME of PKM are shown in Table 5 and the AA ileal digestibilities in Table 6.

Discussion

The bulk density of unmodified PKM is close to other conventional feedstuffs, being 0.67 g/cm³. Grinding to 0.5 mm decreased its bulk density by about 12 %. WHC of PKM is 2.93 g water/g feed. The values of the bulk density and WHC of PKM were better (see Table 4) than those of other agricultural

Table 2. Proximate Composition of Palm Kernel Meal Used In This Experiment

Fractions	Palm kernel meal (%)
Dry matter (%)	94.4
Crude protein (%)	13.6
Gross Energy (K Cal)	4,998
Neutral Detergent Fibre (%)	62.6
Crude fibre (%)	21.3
Lipid (%)	11.1
Ash (%)	2.7

Table 3. Amino Acid Content of Palm Kernel Meal

Amino Acids	PKM (mg/g)	Young birds requirement (NRC, 1994)	The ability of 100% PKM to meet amino acids requirements (%)
Arginine	19. 2	12.5	156
Histidine	3.2	3.5	91
Lysine	4.0	11.0	36
Isoleucine	5.5	8.0	69
Leucine	10.4	12.0	87
Methionine	1.7	(Cys + Meth) 9.0	Cys was not analysed
Phenylalanine	6.4	(Phenyl + Tyrosine) 13.4	66
Threonine	5.3	8.0	66
Valine	7.7	9.0	86
Tyrosine	2.4	(Phenyl + Tyrosine) 13.4	66
Glycine	6.5	(Glycine + Serine) 12.5	114
Serine	7.8	(Glycine + Serine) 12.5	114

Cys: cystine; Meth: methionine; Phenyl: phenylalanine

Table 4. Proximate Composition And Physical Characteristics of Palm Kernel Meal Compared With Other Feedstuffs

Feedstuffs	Bulk density (g/cm^3)		Water holding capacity (g water/g feed)		Relative volume (cm^3/g)
	Unmodified	0.5 mm	0.5 mm	1 mm	
Corn	0.69	0.56	1.71	1.94	4.8
Wheat	0.72	0.66	2.49	3.29	5.3
Rye	0.73	0.57	2.32	3.36	5.8
Triticale	0.69	0.65	3.08	3.47	6.3
Soybean meal	0.73	0.58	2.77	3.30	6.5
Fish meal	0.55	0.53	1.64	1.51	5.0
Millrun	0.36	0.44	4.16	6.64	11.7
Copra meal	0.56	0.49	4.14	4.69	10.6
Palm kernel meal	0.67	0.57	2.93	3.52	6.9

WHC: Water Holding Capacity

by-products, such as millrun. There is a positive correlation between bulk density and bird performance (Mratz et al., 1967) and negative correlation between WHC and feed consumption (Kyriazakis and Emmans, 1995), so it would not be expected that these factors would be a problem when feeding PKM.

Data on nutrient components indicate that PKM has a moderate amount of protein and a high lipid content. The high lipid present in PKM indicates that the PKM used in this experiment was poorly extracted. Published data indicate that ether extract of PKM was in the range between 0.5 and 11.6% (O'Mara et al., 1999). Dietary fibre, on the other hand, was quite high 62.6% NDF. Digestibilities of DM, CP and NDF of PKM were 38.9%, 52.4% and 30.1% respectively.

Table 5. Faecal Digestibility of Nutrients and Apparent Metabolizable Energy of Palm Kernel Meal by Six Week Old Birds

Parameters	(%)
DM digestibility	38.7±0.02
Protein digestibility	48.7±0.02
NDF digestibility	36.2±0.03
Viscosity (cP)	1.54±0.02
AME (MJ/kg)	9.46±0.35

DM: Dry matter; NDF: Neutral detergent fibre; AME: Apparent metabolizable energy; MJ: Megajoule

Table 6. Ileal Amino Acid Digestibility of Palm Kernel Meal by Six Week Old Birds

Amino acids	(%)
Protein	53.6±0.8
Arginine	81.9±0.9
Histidine	60.9±1.9
Lysine	57.2±2.1
Isoleucine	73.3±1.3
Leucine	73.8±1.3
Methionine	71.5±1.4
Phenylalanine	75.9±1.2
Threonine	62.8±1.8
Valine	77.7±1.1
Tyrosine	57.6±2.1
Alanine	72.1±1.4
Glycine	66.8±1.6
Serine	70.3±1.5

It has been reported that most of the dietary fibre in PKM is in the form of mannan (Daud and Jarvis, 1992) which is indigestible by monogastric animals. Data on DM digestibility (38.7%) and NDF digestibility (36.2%) may indicate that most of the dietary fibre in PKM could not be digested. However, even 30% digestibility of fibre indicates that the bird may be gaining some benefit from this source of carbohydrate. Protein digestibility using faecal collection was also low (48.7%). It can be speculated that the protein may be trapped inside the cell wall of the dietary fibre of PKM. However, ileal digestibility of protein was slightly higher, being 53.6%. Since the protein of the faeces is not entirely from the diet, as a large amount is derived from the microbes in the large intestine, along with endogenous protein, the PKM protein faecal digestibility may be an underestimate of true feed protein digestibility.

Lipid digestibility of the diet, on the other hand, was quite high, being about 95%. Although, CP and NDF digestibilities were very low, the AME of PKM was a moderate amount (9.46 MJ/kg). This relatively moderate amount of AME of PKM was probably contributed to by the high digestibility and high quantity of lipid in this PKM sample.

PKM has been reported to be deficient for chickens in most essential AAs, particularly lysine and methionine. The ileal digestibilities of the AAs were between 57 and 82 for lysine and arginine respectively. The digestibility of methionine was also low, being about 72%. The low levels of lysine and methionine in PKM coupled with their low digestibilities necessitates supplementation of these two essential AAs or the use of a considerable amount of protein rich ingredients when PKM is included in the diet in large quantities. It is hard to speculate what is the cause of the low digestibility of lysine and methionine because the other AAs were not as affected as these two amino acids. This low digestibility may be due to the higher content of dietary fibre (Flipot et al., 1971) and heat treatment during processing (O'Mara et al., 1999). However, Nwokolo et al. (1976) found higher AAs availability between 63 and 93% when they measured faecal AA digestibility after correction for endogenous AAs.

CONCLUSION

The physical characteristics of PKM, bulk density and water holding capacity, appear not to present any problems in feeding PKM to broilers since they are very similar to most conventional feedstuffs. However, the digestibility of its nutrients was low.

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