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CHEMICAL COMPOSITION AND DIGESTIBLE ENERGY OF SOME FEEDSTUFFS DETERMINED WITH PIGS IN MALAYSIA

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The gross energy and proximate composition of 18 feed ingredients were determined. Metabolism trials were conducted with growing castrated pigs to assess the apparent digestibilities of dry matter (DM), energy and crude protein of these feedstuffs. DM digestibilities ranged from 38.7% for palm oil sludge to 93.3% for brewers' dried yeast. Digestible energy values on a DM basis, ranged from 8.86 MJ/kg for palm oil to 17.10 MJ/kg for soya bean meal. Digestibilities of crude protein on a DM basis ranged from 49.2% for cocoa husk to 89.9% for fish meal. It was concluded that growth studies should be conducted to determine the economic and nutritional worth of the agricultural by-products in pig diets.

Key words: pigs, feedstuff analysis, digestible energy value, by-products

Malaysia is self sufficient in pork but substantial quantities of both energy feedstuffs and protein concentrates have to be imported from neighbouring countries. It is therefore important to make most efficient use of these feedstuffs by determining their chemical composition and energy availability. Although some feed manufacturers have laboratory facilities to determine the chemical composition of feed ingredients, the smaller feed formulators and farmers have to resort to average values to assess the worth of such feeds. Information on the physical characteristics and chemical composition of a particular ingredient without some biological information is of limited value.

In addition to the traditional imported feed ingredients, the local feed formulators also have available several local feed by-products. These latter feedstuffs are normally cheaper than the imported conventional feedstuffs and often varying amounts of these non-traditional feedstuffs are incorporated into pig diets. Again, there is usually little information on the nutritive values of these by-products and estimated values are often used.

Digestible energy (DE) is the most acceptable system for expressing the dietary energy needs of pigs (Farrell 1978). However, there is insufficient information on DE values of regional feed ingredients and little data on local agricultural by-products. Feed formulators usually use DE values from data from overseas, especially from the ARC (1967) and NRC (1979). However, many of these values were obtained from total digestible nutrients (TDN) using the factor of 18.4 MJ DE kg^{-1} of TDN (Farrell 1979). These data when applied to regional and local feedstuffs, may given misleading values. Moreover, Morgan et al (1975) have shown that there is no precise relationship between DE and TDN.

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The present study was conducted with pigs to determine the apparent digestibility of dry matter (DM), gross energy and crude protein of a range of feedstuffs.

Materials and Methods

Diet and feedstuffs: A commercial pig grower mash of unknown ingredient composition was used as the basis for the evaluation of each of the test ingredients. Initially the apparent digestibility of DM gross energy and crude protein of the basal diet was determined; inclusion of a test ingredient in the basal diet was then carried out to evaluate the test feed. The coefficients of digestibility of the test ingredients were then calculated according to the method of Crampton and Harris (1969). This method was used because it has been shown that substitution of the test ingredient in the basal diet does not normally have an associative effect on the digestibility of dietary components (Farrell 1973 ; Morgan et al 1975). The level of substitution (Table 1) used, is based on the acceptability and the crude fibre content of the test ingredient. A total of 18 feedstuffs were evaluated (Table 1).

Animals and measurements: For each metabolism trial there were four Landrace x Large White x Duroc castrated male pigs (27 to 36 kg) in metabolism crates (see Table 1). The feed (3% of liveweight) was offered twice daily in the ratio of water to feed of 2:1. Water was then freely available. Any feed left was collected and dried and feed intake was adjusted.

Pigs were allowed 4 to 10 days to adapt to the metabolism crates (see Table 1). Total faecal collections were then made over a 5 - day period. Faeces were dried on trays in a forced draft oven at 60°C to constant weight, then allowed to cool and weighed to obtain the total DM for each pig. The faeces from each pig were mixed and a sample taken for grinding in a laboratory mill then stored prior to chemical analysis.

All feed and faecal samples were subjected to proximate analysis according to the methods of the Association of Official Analytical Chemists (1975). Gross energy of feed and faeces was determined in a Parr adiabatic bomb calorimeter.

Results and Discussion

The proximate composition and gross energy values of the feedstuffs tested are summarized in Table 1. As only one sample of each feed ingredient was analysed, the data presented do not indicate the variation of both the chemical and physical composition; Davendra (1979) has reported the chemical composition of a wide range of Malaysian feedstuffs and has pointed out the wide variation in composition existing amongst individual feedstuffs particularly the agricultural by-products, A comparison of the data in the present study shows that with some exceptions , the values are within or close to the range reported by Davedra (1979). One of the exceptions is broken rice; the proximate composition of this feed in the present study is different from that reported. This product sold as broken rice is actually a mixture of broken rice, bran and hulls; analysis of the sample suggests that it resembles bran rather than rice. In

Table 1:

Chemical composition, country of origin, adaptation period, and inclusion rate of feed ingredients in the basal diet

Feed ingredient	Country of origin	Adaptation period (days)	Level of inclusion (%)	Dry matter (%)	Crude protein (%)	Ether extract (%)	Crude fibre (%)	Ash (%)	NFE (%)	Gross energy (MJ/kg)
Maize	Thailand	4	40	87.8	10.6	3.2	2.1	1.6	82.5	18.16
Broken rice[1]	Malaysia	4	40	88.7	15.9	2.2	11.4	4.6	65.9	18.13
Ground sorghum	Thailand	7	40	86.3	9.5	2.8	2.9	3.0	81.8	19.20
Rice bran A	India	4	40	90.6	12.3					18.89
Rice bran B	Thailand	4	40	90.0	13.8	3.8	24.7	13.3	44.4	17.32
Wheat pollard	Australia	4	40	88.1	15.8	3.1	11.5	5.1	64.5	19.90
Brewers dried grains	Malaysia	6	20	90.1	19.0	6.5	16.9	3.5	54.1	20.92
Cocoa husk	Malaysia	10	15	88.9	8.1	0.7	30.6	11.3	49.3	22.61
Copra cake	Malaysia	6	30	87.2	21.3	9.3	13.7	6.4	49.3	22.98
Cassava meal	Malaysia	4	40	89.5	2.8	0.3	3.4	7.1	86.4	16.62
Groundnut meal	Thailand	4	30	89.9	56.9	0.5	10.7	9.7	22.2	18.38
Palm kernel cake	Malaysia	4	30	87.5	16.7	4.9	16.5	6.8	55.1	19.10
Palm oil sludge	Malaysia	6	15	91.2	13.6	16.5	16.7	23.1	16.4	16.99
Brewers dried yeast	Malaysia	6	30	88.0	37.9	0.8	2.4	8.0	50.9	18.34
Soya bean meal	China	4	40	88.4	46.4	1.3	3.5	7.9	40.9	19.21
Fish meal	Thailand	4	30	89.5	57.5	8.8	11.5	21.1	11.1	18.25
Meat and bone meal	Australia	4	30	90.2	43.7	9.3	3.0	32.4	11.6	16.79
Rubber seed meal	Malaysia	6	30	93.5	34.4	8.8	6.5	4.7	45.7	22.25
Basal pig diet				89.0	16.3	4.4	8.2	7.0	64.1	18.31

[1]Old broken rice with substantial quantities of bran and husk and infested with weevils (*Sitophilus oryzae*) and moth larvae (*Corcyra cephalonica*)

addition, the sample studied was heavily infested with weevils (*Sitophilus oryzae*) and larvae of moth (*Corcyra cephalonica*); this may account for it's unusually high crude protein content.

The coefficients of apparent digestibility of DM, gross energy and crude protein and the DE values of individual feedstuffs are presented in Table 2. DM digestibilities of the test ingredients varied from 93.3% for brewer's dried yeast to 38.7% for palm oil sludge. Of the cereals evaluated, maize, broken rice and sorghum had digestibilities of between 86.8 and 90.0%, while the cereal and agricultural by-products showed a progressive decrease due to increasing fibre content. DM digestibilities of the protein feeds were high for brewer's dried yeast and soya bean meal, intermediate for fish meal and the oil meals, and low for meat and bone meal. The DM digestibility of 89.4% and 41.3% for soya, bonemeal and meat meal respectively in the present study are similar to those of Morgan et al (1975) where reported values are 89.3 and 42.5% respectively.

Table 2:

Apparent digestibility of dry matter, gross energy, and crude protein and digestible energy values of feed ingredients and the basal diet on a DM basis

Feed ingredient	Apparent digestibility dry matter (%)	gross energy (%)	crude protein (%)	Digestible energy (MJ/kg)
Maize	90.0 ± 0.4	91.8 ± 0.5	82.1 ± 0.6	16.673 ± 0.084
Broken rice	86.8 ± 0.1	85.9 ± 0.6	82.7 ± 0.6	15.564 ± 0.113
Sorghum	90.0 ± 0.5	86.5 ± 0.3	76.0 ± 1.0	16.598 ± 0.059
Rice bran A	43.8 ± 1.9	55.5 ± 1.9	49.6 ± 2.4	10.464 ± 0.368
Rice bran B	52.3 ± 0.8	59.4 ± 0.6	53.5 ± 1.7	10.297 ± 0.096
Wheat pollard	62.3 ± 0.7	64.4 ± 0.5	59.9 ± 2.1	12.811 ± 0.088
Brewers dried grains	40.5 ± 3.3	49.0 ± 2.7	60.3 ± 1.5	10.247 ± 0.573
Cocoa husk	45.0 ± 2.9	52.9 ± 4.7	49.2 ± 3.0	11.975 ± 1.059
Copra meal	71.8 ± 0.5	66.2 + 1.1	50.2 ± 0.7	15.192 ± 0.264
Cassava meal	85.8 ± 0.6	84.6 ± 0.3	60.9 ± 1.2	14.071 ± 0.054
Groundnut meal	78.0 ± 0.9	84.9 ± 1.0	85.4 ± 0.6	15,740 ± 0.176
Palm kernel meal	74.7 ± 1.1	71.4 ± 0.6	66.4 ± 0.6	13.636 ± 0.121
Palm oil sludge	38.7 ± 2.6	52.2 ± 1.8	51.4 ± 2.0	8.862 ± 0.301
Brewer dried yeast	93.3 ± 0.7	90.8 ± 0.5	84.3 ± 1.4	16.657 ± 0.794
Soya bean meal	89.4 ± 0.5	89.0 ± 0.9	84.6 ± 0.6	17.104 ± 0.172
Fish meal	71.0 ± 0.9	89.3 ± 0.8	89.9 ± 0.4	16.305 ± 0.138
Meat and bone meal	41.3 ± 1.9	50.7 ± 1.9	82.5 ± 1.0	8.514 ± 0.326
Rubber seed meal	70.1 ± 1.4	68.6 ± 0.9	69.9 ± 0.4	13.046 ± 0.192
Basal pig diet	74.8 ± 0.5	76.6 ± 0.4	73.7 ± 0.5	14.029 ± 0.075

Apparent digestibilities of crude protein also covered a wide range from 89.9% for fish meal to 49.2% for cocoa husk All the agricultural by products evaluated showed low apparent protein digestibilities probably due to their high fibre and ash contents. The oil seed residues, copra meal, palm kernels and rubber seed meal, also have relatively low protein digestibilities. It is known that the protein digestibility of a given feedstuff will vary as a result of processing methods used, particularly to processing temperature (Butterworth and Fox 1963). The apparent digestibility of crude protein for copra meal may be cited as an example. The value of 50.2% obtained in the present study is similar to that obtained by Cresswell and Brooks (1971a) who reported a value of 50.7%; however, Loosli et al (1954) reported a much higher value of 73.4%. Thus, the value for a protein source should not be based solely on protein (nitrogen) content, particularly if the protein feed had been subjected to a process which might bring about protein damage. The crude protein digestibility for soyabean meal and fish meal obtained in this study are comparable to values given by the NRC (1968) and the value for meat and bone meal of 82.5% is within the range of 73 to 91% reported by Batterham et al (1980b).

Except for meat and bone meal DE values were high for the cereals and protein feeds. Of the agricultural by-products, the two rice bran samples, brewer's dried grains, cocoa husk and palm oil sludge had DE values below 12.55 MJ/kg on a DM basis. The DE value of cassava at 14.07 MJ/kg is lower than that of 17.51 MJ, reported by Aumaitre (1969). Other workers (Maust et al 1972; Muller et al 1974) have reported that the metabolizable energy (ME) value of cassava is higher or similar to that of maize. Hutagalung et al (1973) however, reported an ME value of 13.51 MJ/kg. When the ME to DE ratio for cassava is 97% (Mesa and Maner, unpublished data), the DE value of 14.07 MJ/kg obtained in the present study would be comparable to that of Hutagalung et al (1973). Differences in the energy value of this feed could be related to variety, age at harvest, country of origin and method of processing.

Table 3 gives a comparison of DE values from various sources. The DE values of maize and sorghum in this study were comparable to those

Table 3:
Comparison of published DE values of feedstuffs (MJ/kg DM) with those in this experiment

Ingredient	Present experiment	A	B	C	D	E
Maize	16.673	16.820	16.736	16.485	16.569	
Sorghum	16.598	16.610	15.732	15.857	16.167	15.949-17.113
Rice bran	10.381				14.159	
Wheat pollard	12.811	13.514			14.498	13.188-15.493
Brewers dried grains	10.247				8.824	
Groundnut meal	15,740	17.866			13.226	
Soya bean meal	17.104	17.740	18.368		15.749	
Fish meal	16.305	16.694[2]	15.021[3]		13.883[4]	
Meat and bone meal	8.514	8.828			12.891	10.050-14.263

A Morgan et al (1975) B Diggs et al (1965) C Robinson et al (1965)
D NRC (1979) E Batterham et al (1980a & 1980b)
[2]White fish meal [3]Menhaden [4]Herring

reported by other workers, The small variation in DE content of these two cereals supports the contention of Morgan et al (1975) and Batterham et al (1980a) that there are only small differences in the average values of cereals from various parts of the world. Thus feed formulators can use values from feeding standards with confidence. The DE value for rice bran is much lower than that given by the NRC (1979). This was due to the poor quality of the samples evaluated; the crude fibre content of one of the samples studied was 24.7% whereas that of the NRC sample was only 12.5%. It is well documented that increasing dietary fibre levels will depress the DE values of feed (Bowland et al 1970; Henry 1976; Kornegay 1978).

There is considerable variation in the DE values for wheat pollard reported by different workers. This probably is due to the different rate of extraction of flour during the milling process.

The DE values for groundnut meal, soyabean meal and fish meal in the present study are in general accord with those of other workers except that given by NRC (1979) which are considerably lower. The DE of meat and bone meal is comparable to that of Morgan et al (1975) but lower than that reported by Batterham et al (1980b). These latter workers showed that there is considerable variation in the DE content of this feedstuff as a result of variation in the ether extract and bone contents.

It is not possible to compare the DE values obtained for the other agricultural by-products, (cocoa husk, copra cake, palm kernel meal, palm oil sludge and rubber seed meal), as we are not aware of other published data. The evaluation of the suitability of some of these feeds in swine diets has been reported by Thrasher et al (1966) for rice bran; by Adeyanju and Ilori (1979) for cocoa husk; by Creswell and Brooks (1971b) for copra meal and by Ong and Yeong (1977) for rubber seed meal. The usual method is the direct substitution in a diet of the by-product for maize or soyabean meal. Under practical commercial conditions however, a few of these by-products are used to replace cereals or conventional protein sources in a pig's diet. Due to their high fibre or ash content and also the doubtful bio-availability of protein, pig performance in terms of growth rate and feed efficiency could be very adversely affected by diets containing substantial quantities of these products. Growth studies are needed to determine the economic and nutritional worth of these by-products in pig diets.

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