

The Composition, Nutrient Digestibility and Energy Value of Maize Cobs, Yam Peels and Plantain Peels for Three Weight Groups of Pigs

By

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SUMMARY

THE proximate and mineral composition of yellow maize (YM), maize cobs (MC), yam peels (YP) and plantain peels (PP) were determined. Their digestion coefficients for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and nitrogen-free extract (NFE) were determined with 48 pigs at 18, 45 and 65 kg liveweight. In a second trial 60 pigs of similar weights were used to determine the digestible energy (DE), metabolizable energy (ME) and nitrogen corrected ME (ME_n) for a basal diet and these feeds in diets in which 40% by weight of the test ingredients were added to the basal diet. The digestion coefficients of DM, CP, CF and EE for YM (92.0, 86.0, 76.7 and 88.6% respectively) were significantly better than the values of 83.4, 54.2, 71.7 and 38.4 and 79.5, 57.7, 70.2 and 55.7% observed for YP and PP respectively. MC had significantly the least digestion coefficients for these nutrients (27.9, -18.5, 51.7 and 17.1%). The 18 kg pigs digested DM and CF to a lesser extent than the 45 or 65 kg pigs. There were no significant differences in CP, EE and NFE digestibility between weight groups. The DE and ME values of 3.14 and 2.98 and 3.15 and 2.94 kcal/g for YP and PP respectively were identical but significantly lower than the values of 4.0 and 3.68 for YM, MC had significantly the least DE, ME and ME_n values. The ME_n values of 3.49, 2.95 and 2.94 kcal/g for YM, YP and PP were not significantly different. There were no significant differences in DE, ME or ME_n between the weight groups.

INTRODUCTION

MAIZE, and, to a lesser extent, guinea corn have remained the major energy sources in diets for pigs and poultry in this country, contributing 60-80% of the total diet. The current prohibitive prices of these cereals stemming directly from their high demands as staple human foods in

many areas of the developing world creates problems of rising feed costs. The future for efficient and profitable production of meat from pigs and poultry would therefore depend on finding cheaper alternative sources of energy not directly required as components of human dietaries. The peels from yams (*Dioscorea* sp.), plantains (*Musa* sp.) and maize cobs, are all by-products not directly utilizable by humans. Estimates by Olayide, Olatunbosun, Idusogie and Abiagom, (1972) show that in 1969/70, production of maize, yams and plantains stood at 1.6, 15.2 and 0.97 million metric tons respectively. Olusanya, 1974 (unpublished data) estimated that maize cobs comprised about 16.7% of the whole maize ear, yam peels approximately 30% of the whole tuber, while plantain peels comprised about 37.5% of the whole plantain. Viewed against the 1969/70 production figures, about .26, 4.6 and .36 million metric tons of maize cobs, yam and plantain peels respectively probably went to waste. With increased cultivation and production, greater quantities of these by-products are likely to become available and it is envisaged that these could be converted to valuable animal protein for human consumption using such animals as the pig. Their use in this direction however demands a knowledge of their composition and energy

values. Oyenuga (1968) reported proximate composition values for yam peels from several varieties of yam grown in Nigeria as well as for maize cobs and plantain peels. Apart from this, there appears to be little or no report on the digestion and utilization of these by-products by pigs. The study reported here was, therefore, conducted to determine the digestion coefficients and energy values of maize cobs, yam and plantain peels to different weight groups of pigs.

MATERIALS AND METHODS

The yellow maize and maize cobs used were obtained from the University of Ibadan Teaching and Research Farm, while the yam and ripe plantain peels were collected from the Central Catering Department, also at the University of Ibadan. The maize cobs, yam and plantain peels were all sun-dried and then finely ground before use.

Chemical analyses

All samples were analysed for their proximate constituents using the methods of the Association of Official Analytical Chemists (AOAC, 1970). Mineral analyses were carried out after wet-ashing of the samples with a mixture of nitric, perchloric and sulphuric acids, using a Perkin-Elmer atomic absorption spectrophotometer 290. The phosphovanadomolybdate method (AOAC, 1970) was used for the estimation of phosphorus, while the gross energy determinations were carried out with a Gallenkamp oxygen ballistic bomb calorimeter.

Animal studies

The first series of metabolism trials were conducted to determine the digestion coefficients for the feed to three weight groups of pigs. A total of 48 Large White

barrows were used in three consecutive metabolism trials involving 16 pigs each, weighing 18, 45 and 65 kg in the first, second and third trials respectively. The feeds were offered as the only source of nutrients. The yellow maize (YM) served as a positive control in the three metabolism trials. Each trial comprised a 7-day preliminary period, followed by a 7 day collection period in specialised metabolism cages (Oyenuga, 1961). The feeds offered during the collection period in all cases were 15% below observed intake during the preliminary periods. Chromic oxide was added to the feed on the first and seventh days of the collection period and faeces collected in the interval between the 1st and 7th days. Daily faecal output for each animal was measured and samples taken and stored in a refrigerator at approximately -5°C until the end of the collection period when an aliquot of the combined faecal samples for each pig were dried in a forced air circulation oven at 85°C for 72 hr., allowed to equilibrate with air moisture, and then ground to pass through a 30mm screen using a small laboratory mill. The feeds and faeces were then analysed for their proximate constituents using the method of the AOAC (1970).

In the second series of metabolism trials to determine the DE, ME and ME_n in the feeds and a basal diet (table 1), Large White barrows were used and the experiment comprised three separate metabolism trials employing 20 pigs each at 18, 45 and 65 kg. The test ingredients were added to the basal diet at a level representing 40% by weight of the final test diet and the DE, ME, and ME_n determined by the method described by May and Bell (1971). Each metabolism trial also comprised of a 7-day preliminary, followed by a 7-day collection period and the conduct of the trials was exactly

TABLE 1
Composition of Experimental Diets

Items	Dietary treatments				
	1	2	3	4	5
Yellow maize	—	40.0	—	—	—
Maize cobs	—	—	40.00	—	—
Yam peels	—	—	—	40.00	—
Plantain peels	—	—	—	—	40.00
Cassava flour-a/	48.00	8.00	8.00	8.00	8.00
Basal-b/	51.50	51.50	51.50	51.50	51.50
Vit-Min-Premix-c/	0.50	0.50	0.50	0.50	0.50

-a) The cassava flour used in this study had been earlier evaluated and found to yield 4.04 kcals/g digestible energy and 3.91 kcals/g metabolizable energy (Oyenuga and Fetuga, 1974).

-b) The basal diet had the following percentage ingredient composition: maize, 65.90; groundnut meal, 17.50; fish meal 4.80; blood meal, 4.3; rice bran, 2.50; oyster shell, 1.0; dicalcium phosphate, 1.50; palm oil, 2.50.

-c) A Pfizer Product supplying the following vitamins per kilogram of diet: A, 9823 IU; D₃, 1965 IU; B₁₂, 10 ug/ton; Riboflavin, 41 mg; Niacin, 246 mg; Pantothenic acid 98 mg; Folic acid, 10 mg; and the following trace minerals per kilogram of diet; manganese, 341 mg; Copper, 244 mg; Zinc, 100 mg; Iodine, 20 mg, and Oxytetracycline hydrochloride, 20 g/ton.

similar to the first series for the determination of the digestion coefficients except that in this case, total urine production was measured for each animal and aliquots taken and filtered for analytical determinations. Combustible energy was measured for feed, faeces and urine using a Gallenkamp oxygen ballistic bomb calorimeter. Nitrogen determinations were also carried out on feed, faeces and urine using the Standard Kjeldahl procedure. The determined value of 6.77 kcal/g of pig urinary nitrogen (Diggs, Becker, Terril and Jensen, 1965) was used to adjust urinary energy to nitrogen equilibrium.

Digestion coefficient data and energy values were subjected to analysis of variance, treatment means were compared by the Duncan's multiple range test, while over all mean and weight group means were compared using the Student's "t" test (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Chemical and Mineral Composition

The chemical and mineral composition of yellow maize (YM), maize cobs (MC), yam peels (YP) and plantain peels (PP) are summarized in table 2. The crude protein content of PP was comparable to that of YM, while that for YP was slightly lower. Ether extract content of MC and YP were low, while YM had a value about half the quantities recorded for PP. The crude fibre content of MC was clearly higher than for all the other sources. Identical values for ash were observed for YM and ME, while a higher value was recorded for YP. Plantain peels had the highest value for ash compared to the other feeds. Similar gross energy values were obtained for YM, MC and PP, while YP had a lower value. Yam peel was noticeably richer than the other feeds in

TABLE 2

The Proximate and Mineral Composition of the Experimental Feedstuffs (% dry matter)

	<i>Yellow maize (YM)</i>	<i>Maize cobs (MC)</i>	<i>Yam peels (YP)</i>	<i>Plantain peels (PP)</i>
Dry matter	84.5	95.5	82.3	86.2
Crude protein	11.8	2.5	8.2	10.2
Crude fibre	1.3	32.6	7.5	6.3
Ether extract	3.9	0.9	0.7	7.1
Ash	3.4	3.9	7.3	16.3
Nitrogen-free-extract	79.6	60.1	76.3	71.1
Gross energy (kcal/g)	4.3	4.6	3.8	4.6
Calcium	0.004	0.16	0.13	0.07
Phosphorous	0.34	0.06	0.21	0.27
Magnesium	0.11	0.12	0.08	0.11
Potassium	0.32	0.89	1.24	4.49
Sodium	0.033	0.06	0.02	0.006
Manganese	0.001	—	0.002	0.003
Iron	0.006	0.001	0.01	0.008
Zinc	0.004	0.002	0.003	0.004
Copper	0.001	0.001	0.002	0.0008
Chloride	0.28	0.34	0.28	0.22

potassium and sodium while maize cobs had low amounts of phosphorous and traces of manganese. The contents of most other mineral elements were fairly identical. The present analytical data for these feeds are in agreement with similar report by Oyenuga (1968).

Apparent digestibility of nutrients

The mean digestibility of nutrients in YM, YP and PP by pigs at three weights are presented in table 3, while the overall mean digestion coefficients are summarised in table 5. Overall mean digestible dry matter, crude protein, crude fibre and ether extract for maize were significantly ($P < 0.05$), higher than for all the other feeds. Yam peels and plantain peels had non-significantly different digestible crude protein, crude fibre and nitrogen free extract but the ether extract in plantain peels was significantly ($P < 0.05$) better digested than that in yam peels. Maize cobs had significantly the least digestion coefficient for all the nutrients, the values for crude protein and ether extract being negative.

The results for nutrient digestibility would appear to be closely related to the crude fibre contents of the different feeds. Yellow maize with the lowest content of crude fibre had the best digestion coefficient for all the nutrients while plantain peels and yam peels with fairly identical crude fibre contents showed identical digestion coefficients for most of the nutrients. Maize cobs with the highest fibre content showed the poorest digestion coefficients for all of the nutrients. Pond, Lowrey and Maner (1962) and Bell, Bowland, Cameron, Crampton, Lloyd, Seale and Whiting (1958), have all indicated the overall digestibility of a diet or feed to be related to its crude fibre content, the digestibility declining with increasing crude fibre content of the feed. Van Soest and McQueen (1973) described the 'crude fibre' fraction of a diet or feed as being made up of lignin, cellulose, hemicellulose and other pentosans, and further stated that these fractions in different plant materials are not chemically similar. Studies by Laurentowska (1950) showed

the digestibility of ligning, cellulose, and pentosans by pigs to be of the order of 52, 35 and 5% respectively. The variation in digestion coefficients of the so called crude fibre in these feeds may be as a result of source and type of fibre reflecting their chemical and physical composition as well as biological properties. The greater depression in the digestion coefficients of other nutrients in maize cobs may also be entirely attributable to its high fibre content and perhaps to a greater degree of lignification compared to the other sources. Southgate and Durnin (1970) had observed that as the intake of unavailable carbohydrate increased the apparent digestibility of other constituents in a diet decreased, while Van Soest *et al.* (1973) suggested that reduction in nutrient digestibility in feeds with high degree of lignification may be as a result of an encrusting effect of the ligning thereby preventing enzymic attack of other soluble and digestible fractions.

Maize cobs also showed negative values for ether extract and crude protein digestibility. This may not represent the true value of the digestion coefficients of the very small quantity of ether extract present in maize cobs and its low level of protein. The negative values obtained may have resulted from an increased activity of the microflora in the caecum in response to the presence of the high level of crude fibre in the diet with a consequent rise in the ether-soluble and nitrogenous compounds excreted in the faeces. These compounds could have been derived from mechanical erosion of the mucosal surface leading to increased losses of endogenous material, bacterial lipid and protein from dead bacteria and their presence in the faeces could result in amounts of ether-soluble substances and nitrogen in excess of those derived from undigested fractions of ether extract and nitrogen in maize

cobs. Whiting and Bezeau (1957) have shown increased excretion of metabolic faecal nitrogen in response to high fibre levels in diets and for feeds like the maize cobs with low contents of nitrogen, the increased excretion of metabolic faecal nitrogen may account for the negative apparent digestibility value for protein.

Weight group means (Table 3), showed significant differences between weight groups for the digestion of dry matter and crude fibre but not for the other nutrients, only the difference between the 18 kg pigs on the one hand and the 45 and 65 kg on the other being significantly different. The absence of differences in the digestion coefficients for crude protein, ether extract and nitrogen free extract between the weight groups is in consonance with the report by Lawrence (1967) who had observed no clear indication that digestibility of any one fraction of the diet either decreased or increased with liveweight of animal, while the results for dry matter and crude fibre were at variance with this. It should be noted, however, that the report by Lawrence (1967) dealt with cereals of fairly low fibre contents, while the present report deals with some fairly fibrous feeds. The lower digestibility of crude fibre and therefore dry matter by the 18 kg pig, particularly in maize cobs may be expected from a consideration of a poorer development of the caecum at this stage, therefore limiting the ability of this weight of pig to degrade dietary crude fibre. Castle and Castle (1957) had shown that rates of passage of diets in the gastro-intestinal tract were faster in lighter than in heavier pigs, while Southgate and Durnin (1970) had observed with human subjects that the longest transit time tended to show the greatest apparent digestibility of cellulose. The longer transit time and the better development of the caecum in the heavier pig

TABLE 3

Mean Nutrient Digestibilities (%) for Yellow maize, Maize cobs, Yam peels and Plantain peels as determined at three weights (18, 45 and 65 kg) of growing pigs.

Pig wt. (kg)	Feeds	Digestion Coefficients (%)									
		Dry matter	±SE	Crude Protein	±SE	Crude Fibre	±SE	Ether extract	±SE	Nitrogen-free extract	±SE
18	YM	91.7a	1.44	85.2a	1.68	56.7a	1.22	89.0a	2.42	95.6a	1.04
	MC	9.0c	0.68	-24.6c	0.74	31.7c	0.45	-44.8d	4.74	20.9b	0.36
	YP	85.4a	1.79	67.6b	1.48	51.9ab	1.38	42.8c	2.11	94.8a	0.98
	PP	78.4b	1.86	59.2b	1.92	48.9b	1.42	65.1b	2.04	89.9a	1.21
	Mean	66.1x	2.11	46.9y	1.97	47.3x	1.18	38.0y	2.86	76.3y	1.18
45	YM	91.5a	1.36	84.9a	1.57	86.4a	1.49	86.2a	1.88	94.3a	1.04
	MC	27.3c	1.06	-22.8d	1.22	58.6c	1.32	-4.1d	1.28	58.8b	1.24
	YP	83.4b	1.69	54.4c	1.62	77.5b	1.77	35.2c	1.38	90.2a	1.33
	PP	83.5b	1.82	66.4b	1.86	81.2ab	1.58	63.0b	1.78	86.2a	1.42
	Mean	71.4y	1.64	4.7y	1.79	75.9y	1.74	45.1y	1.87	82.4y	1.38
65	YM	92.8a	1.52	87.8a	1.48a	87.2a	1.53	90.6a	1.86	95.4a	1.24
	MC	47.3c	1.14	-8.1d	1.03	64.8c	1.28	-2.3c	1.84	64.4c	1.26
	YP	81.4b	1.74	40.5c	1.44	85.8ab	1.48	37.2b	1.76	88.6b	1.18
	PP	76.7b	1.83	47.4b	1.58	80.4b	1.62	39.0b	1.68	81.7b	1.27
	Mean	74.6y	1.84	41.9y	1.73	79.6y	1.63	41.1y	1.92	82.5y	1.22

In this and in subsequent tables, YM = Yellow maize; MC = Maize cobs; YP = Yam peels; PP = Plantain peels. SE = Standard error of means.

a-c = Within weight groups values in the same column, with the same letter are not significantly different ($P > 0.05$).

x,y, Weight group means in the same column followed by the same letters are not significantly different ($P > 0.05$).

TABLE 4

Mean Digestible and Metabolizable Energy (kcal/g dry matter) for Yellow maize, Maize cobs, Yam peels and Plantain peels as determined at three weights (18, 45 and 65 kg) of growing pigs

Pig wt. (kg)	Feeds	Digestible energy (DE)		Metabolizable energy (ME)		ME_n		DE (%)		ME (%)	
		Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE
18	YM	3.98a	0.09	3.66a	0.14	3.53a	0.16	94.1a	1.84	92.2	1.32
	MC	0.62c	0.21	0.58c	0.20	0.59c	0.09	13.5c	0.96	94.2	1.48
	YP	3.23b	0.18	3.06b	0.09	2.97b	0.18	91.2a	1.82	95.0	1.24
	PP	3.18b	0.17	2.95b	0.18	2.89b	0.22	70.4b	1.64	92.9	1.23
	Mean	2.75	0.19	2.56	0.16	2.50	0.19	67.3	1.79	93.6	1.34
45	YM	3.95a	0.14	3.64a	0.18	3.46a	0.17	93.4a	1.88	92.1	1.14
	MC	1.04c	0.17	0.98c	0.17	1.01c	0.19	22.6c	0.84	94.7	1.28
	YP	3.12b	0.22	2.97b	0.24	2.97b	0.16	88.1a	1.79	95.2	1.32
	PP	3.22b	0.23	3.00b	0.22	3.04ab	0.20	71.2b	0.98	93.5	1.21
	Mean	2.83	0.19	2.65	0.21	2.62	0.20	68.8	1.64	93.9	1.28
65	YM	4.06a	0.21	3.73a	0.19	3.49a	0.21	94.6a	1.67	93.2	1.14
	MC	1.24c	0.16	1.17c	0.09	1.20c	0.18	27.0d	1.04	94.2	1.22
	YP	3.06b	0.24	2.90b	0.21	2.91b	0.17	86.4b	1.74	94.8	1.23
	PP	3.04b	0.18	2.87b	0.21	2.88b	0.23	67.3c	1.28	94.3	1.19
	Mean	2.85	0.21	2.67	0.18	2.62	0.21	68.8	1.82	94.1	1.23

compared to the lighter pig may explain the greater ability of heavier pigs to digest the fibre fractions.

Energy Value

The digestible energy (DE), metabolizable energy (ME) and nitrogen-corrected ME, (ME_n) for the different feeds at three different live-weights are presented in table 4, while the overall means are summarised in table 5. With each weight group, yellow maize (YM) had significantly ($P < 0.05$) higher DE, ME and ME_n than yam and plantain peels (YP and PP), except for the 45 kg pig, where the ME_n for PP though lower than for YM, the differences were not significant. Maize cobs (MC) had significantly the least DE, ME and ME_n compared to the other feeds, while the values for yam peels and plantain peels were identical. Expressed as a percentage of gross energy (GE),

the DE for YM was highest while that for ME was least. Though the DE for YP and PP were identical, these values expressed as a percentage of GE were significantly lower for PP. The similar DE and ME values obtained were as a result of a higher gross energy value of PP probably associated with a higher ether extract content. The standard errors for DE, ME and ME_n were similar suggesting little difference between these energy measures for pig feeds. The metabolizable energy values expressed as a percentage of the DE ranged between 92 and 95%, indicating a remarkable efficiency of utilization of DE by pigs for metabolic purposes and therefore strengthening the claim that DE values would suffice in feed formulation for pigs. There were no significant differences between the values for DE, ME and ME_n for the 18, 45 or 65 kg pigs, although there was a very slight

TABLE 5

Overall means⁺ for Nutrient Digestibilities (%) and Digestible and Metabolizable Energy (kcal/g dry matter) for Yellow maize, Maize cobs, Yam peels and Plantain peels as determined at three weights (18, 45 and 65 kg) of growing pigs

	Yellow maize (YM)	Maize cobs (MC)	Yam peels (YP)	Plantain peels (PP)	SE of means
<i>Nutrient digestibility (%)</i>	90.0a	27.9c	83.4b	79.5b	3.24**
Dry matter	90.0a	27.9c	83.4b	79.5b	3.24**
Crude protein	86.0a	-18.5c	54.2b	57.7b	2.44**
Crude fibre	76.7a	51.7c	71.1b	70.2b	1.82**
Ether extract	88.6a	-17.1d	38.4c	55.7b	2.48**
Nitrogen-free extract	95.1a	48.0c	91.2ab	85.9b	1.49**
<i>Energy Value (Kcal/g dry matter)</i>					
Digestible energy (DE)	4.0a	0.97c	3.14b	3.15b	0.28**
Metabolizable energy (ME)	3.68a	0.91c	2.98b	2.94b	0.22**
N-Corrected Metabolizable energy (ME _n)	3.49a	0.92b	2.95a	2.94a	0.21**
DE as % of GE	94.0a	21.0d	88.6b	69.6c	1.46**
ME as % of DE	92.5a	94.4a	95.0a	93.7a	1.34(ns)

**Highly significant treatment differences ($P < 0.01$)

(ns) = no significant treatment differences ($P > 0.05$)

a, b, . . . Row values followed by the same letters are not significant different ($P > 0.05$).

+ Mean values given are those averaged from results obtained to mean liveweights of 18, 45 and 65 kg liveweight. Values for each feed are averages of 12 results (4 pigs at 3 liveweights).

indication of increased energy values at heavier weights. This increasing tendency was more marked for maize cobs. The much lowered digestible energy value for MC may be associated with the markedly lowered digestibility of its nutrients associated with the quantity and nature of the crude fibre in this source. Differences in the energy values of different feeds may be explained in terms of the radical differences in their chemical composition. Starch and sugars are the predominating source in the N.F.E. fraction of the common feeds, providing the major portion of the energy (available carbohydrates), the crude fibre fraction falls into the group described as unavailable and variable contributions to the overall energy value may result from the digestibility of these fractions differing from one material to another. The efficiency of utilisation of ME for maize cobs (ME as percent of DE) was comparable to that in the other sources despite its high fibre content. This finding is supported by the claim by Carpenter and Clegg (1956), that while fibre may actively depress productive energy (due to work used in propelling it through the gut or for other reasons), the metabolizable energy is unaffected.

The results of this study indicate that while maize has a better overall digestibility of its nutrients and higher DE, ME, ME_n compared to yam peels and plantain peels, these two sources which are at present unutilised could serve as valuable sources of energy in diets for pigs. Maize cobs, because of its particularly low digestibility and low DE, ME and ME_n, may not contribute much to any diet in which it is included, but may find use in diets for fattening pigs as an energy diluent to restrict their digestible energy intake and, may be, enhance carcass quality.

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