The Effects of Graded Levels of Cane Molasses on the Performance Characteristics, Nutrients Utilization and Economy of Production of Yorkshire Pigs Reared in the Tropics

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SUMMARY

Sixty Yorkshire weaner pigs were used in this trial designed to study the effects of high cane molasses levels in the diets of pigs on their performance and carcass characteristics, organ weights, nutrient utilization and on the economy of production. There were five diets formulated to contain 23% protein (dry matter basis) and differed in the levels of mollasses that were included at 0, 10, 20, 30 and 40%. The Yorkshire barrows and gilts used were randomly divided into 5 equal treatment groups of 12 pigs, made up of 6 barrows and six gilts, and of equal average initial live weight of about 17kg. Half of the pigs on each treatment were group-fed ad libitum, and half were individually fed. They were all slaughtered at the average final liveweight of about 65 kg. Highly significant treatment differences were obtained in the average daily gains, average daily dry feed and dry matter consumed/kg body weight, dressing percentage, carcass length, back fat thickness, percentages of ham and loin, trimmed and dissected fat, dissected bone, gut weight, fresh liver, heart, and kidney weights. There were no differences in the digestibility coefficients of dietary nitrogen, NFE and ether extract, but the differences were significant for the crude fibre digestibility. The N retained was also significantly influenced by the level of molasses, while the percentages of ME and DE utilized were not significantly altered by the molasses. The inclusion of cane molasses considerably reduced the cost per ton of feed, and resulted in higher gross revenues gained per pig relative to the control.

INTRODUCTION

ONE of the major problems confronting pig producers in many tropical countries is the scarcity of suitable basal energy feeds. This scarcity arises not only through the under-production of these feeds, but also because humans also consume a considerable amount of the annual yields leaving very little for the animals. More recently, the increases in food prices all over the world have complicated more the already bad situation, and this particular problem has stimulated researches into the possibilities of using cheaper substitutes to reduce feed prices without adversely affecting the performances of the animals. Here in Nigeria, maize and guinea corn have traditionally served as the basal energy sources in the diets of monogastric animals. The feeds being investigated are cassava, sweet potato, and cane molasses. Of these three new sources, molasses offers an attractive possibility because it is both cheap and uncompeted for by man who cannot consume it in his diet. While there is some information on the value of molasses in the diets of pigs in some parts of the world (Blanco, Raun and Vargas, 1964; Iwanaga, Otagaki, Cobb and Wayman, 1959; Brooks and Iwanaga, 1967; Preston, 1969; Brooks 1967, 1972), there is no information on the degree to which this industrial waste product can be utilised in Nigeria and indeed in Africa. The trial being reported here was therefore conducted to investigate the effects of adding cane molasses to the diets of pigs on the performance characteristics, organ weights, and carcass quality; the optimal level of inclusion of the

TABLE 2

Composition of Experimental Rations

Ingredients	Dietary composition (% Air dry) 1	2	3	4	5
Ground yellow maize	67.0	55.2	43.3	31.5	19.5
Groundnut meal	16.0	17.5	19.0	20.5	22.0
Blood meal	4.0	4.3	4.7	5.0	5.5
Rice bran	10.0	10.0	10.0	10.0	10.0
Cane molasses	0.0	10.0	20.0	30.0	40.0
Oyster shell	1.0	1.0	1.0	1.0	1.0
Dicalcium phosphate	1.5	1.5	1.5	1.5	1.5
Vit. - Min. - Premix-a/	++	++	++	++	++
Salt	0.5	0.5	0.5	0.5	0.5
Totals	100.0	100.0	100.0	100.0	100.0
*Analysis of dry matter,*b/ (%)					
Dry matter	87.06	84.69	83.20	81.30	80.55
Crude protein	23.08	23.02	22.87	23.81	23.61
Crude fibre	5.03	5.57	5.86	5.24	5.51
Ether extract	3.11	3.27	2.68	2.93	2.54
Total ash	6.10	5.27	6.00	6.27	6.61
Gross energy, kcal/g	4.06	4.35	4.45	4.74	4.61

-a/ A Pfizer Livestock Feeds product, supplying the following vitamins and minerals per kg. of diet: A, 9823 IU; D_3 1965 B_{12}, 10 ug/ton: Riboflavin, 41mg: Niacin, 246 mg; Pantothenic acid, 98mg; Folic acid, 10mg; Manganese, 341mg; Copper, 244mg; Zinc, 100mg; Iodine, 20mg and Oxytetracycline hydrochloride, 20 g/ton.

-b/ Proximate analysis by the AOAC methods, 1970.

TABLE 3

The Essential Amino Acid composition of the Experimental Rations

Amino acids	Calculated dietary levels, % 1	2	3	4	5
Arginine	1.62	1.56	1.60	1.63	1.68
Histidine	0.86	0.74	0.73	0.71	0.69
Isoleucine	0.67	0.58	0.56	0.54	0.53
Leucine	2.09	1.78	1.71	1.64	1.59
Lysine	0.85	0.83	0.84	0.85	0.88
Methionine + Cystine	0.40	0.38	0.36	0.35	0.36
Phenylalanine + Tyrosine	2.04	1.81	1.80	1.55	1.77
Threonine	0.83	0.71	0.69	0.67	0.66
Tryptophan	0.18	0.17	0.17	0l18	0.18
Valine	1.09	0.97	0.97	0.96	0.97

ssimus dorsi) opposite the 10th rib, and then the carcass was dissected into lean fat, and bone components and weighed. The fresh weights of the liver, kidney pairs, empty gut, and heart were also recorded.

All the weight, feed records, carcass and organ measurements of the pigs were combined for each treatment (full-fed plus semi-restricted) and these were subjected to analysis of variance and the LSD test wherever significant differences were indicated (Steel and Torrie, 1960) Costing of the operation was based on the prevalent prices of the ingredients and the pigs at the time of experimenting and labour costs which were common to all the treatments were ignored. Nutrient utilization studies were carried out by keeping 3 pigs from each treatment in pig metabolism cages for two weeks, the first seven days for adaptation and adjustment, while the last seven days were for faecal and urine collections. The analyses of the proximate components for the feeds, faeces and urine were done by the AOAC methods (1970).

RESULTS

The treatment means for the performance characteristics, organ weights plus carcass measurements, and nutrient utilization appear in tables 4, 5 and 6 respectively.

Performance Characteristics

Average daily gains (ADG). The best ADG was obtained from pigs on the 10% molasses, and the rate thereafter declined gradually, but the poorest gainers were those on diet 1. Pigs on diets 2 and 3 grew at a highly significantly faster rate than those on diet 1, ($P < 0.01$) while the growth rate of pigs on diet 2 was significantly greater than those on diets 4 and 5 ($P < 0.05$).

Average daily feed, dry matter, and DE consumed. None of these parameters was significantly influenced by the levels of

TABLE 4

Performance Characteristics of Yorkshire Growing-Fattening Pigs Fed Graded Levels of Cane Molasses

Characteristics	*Treatment means* 1	2	3	4	5	*SE means*	*Coefficient of variation %*
Level of molasses, %	0.0	10.0	20.0	30.0	40.0	—	—
Average initial liveweight, kg.	16.7	17.1	17.3	17.2	17.3	—	—
Average final liveweight, kg.	63.2	65.0	65.6	64.6	65.1	—	—
Average daily gain, kg.	0.62	0.71	0.69	0.66	0.66	0.013**	6.17
Average daily dry feed consumed kg.	1.83	1.88	1.84	1.78	1.84	0.062	8.39
Average daily dry feed consumed kg. weight gained	2.80	2.63	2.64	2.58	2.95	0.072**	6.48
Average daily air dry feed consumed, kg.	2.10	2.21	2.22	2.16	2.28	0.065	7.29
Average air dry feed consumed kg. weight gained	3.22	3.11	3.17	3.27	3.66	0.075	5.64
Average daily DE consumed, Mcal.	6.34	6.93	7.01	6.90	7.17	0.209	7.37

* = Significant differences among treatment means ($P < 0.05$).
** = Highly significant differences ($P < 0.01$).

dietary molasses, and the figures were remarkably similar for all treatments, although the average daily DE consumed was increased though not significantly, by the cane molasses, the molasses-free diet 1 having the lowest DE consumed.

Efficiency of feed utilization. When expressed either on air dry or dry matter basis, the efficiency of feed utilization was highly significantly influenced by the levels of cane molasses. In both cases, the highest ratios were obtained for the pigs consuming the 40% cane molasses diet. When expressed on DM basis, the lowest ratio obtained from pigs on diet 4, was highly significantly lower than the ratio for pigs on diet 5 ($P < 0.01$), while the other low ratios obtained for pigs on diets 2 and 3 were significantly lower than that for diet 5 ($P < 0.05$). On air dry basis, the highest ratio on diet 5 was highly significantly higher than the ratios on diets 2 and 3 ($P < 0.01$) and 2 and 4 ($P < 0.05$).

Effiects on Carcass Measurements

Of all the carcass measurements taken (table 5) only the average warm dressing percentage, carcass length, backfat thickness, ham and loin expressed as percentages of chilled carcasses, percentages of trimmed fat, dissected fat and bone showed significant treatment differences due to molasses. There were no significant differences in the loin eye area, the total percentage yield of the lean cuts, percentage shoulder, the percent fat cut, and the dissected lean.

Pigs on diets 3 and 5 had significantly lower dressing percentages than those on diet 1 ($P < 0.01$); those on diet 5 also had significantly lower dressing percentages than those on diet 2 ($P < 0.05$) while pigs on diet 4 were also significantly lower than those on diet 1 ($P < 0.05$).

The average carcass length of pigs on diet 1 was highly significantly lower than the averages for pigs on diets 2, 4 and 5 ($P < 0.05$) and 3 ($P < 0.01$). Pigs on diet 3 had the longest carcasses and those on diet 1 the shortest carcasses.

The average backfat measurements for pigs on diets 4 and 5 were highly significantly lower than those on diets 1 and 2 with the thickest backfat ($P < 0.01$) while the backfat measurement for pigs on diet 3 was also significantly lower than the average for pigs on diet 1 ($P < 0.05$).

Pigs on diets 1 and 2 had significantly lower percentages of ham than those on diets 4 and 5 ($P < 0.05$). The general trend here was clearly that of increasing percentages of ham as the dietary levels of cane molasses increased. The trend with the loin percentage was also that of increasing percentages with increases in levels of molasses. However, the highest loin percentage was obtained from pigs on diet 4, closely followed by pigs on diet 3, and the lowest was from pigs on diet 1 which had significantly lower loin percentage than those on diets 3 and 4 ($P < 0.05$).

Both the percent trimmed fat and dissected fat were significantly depressed by the increases in molasses levels. The lowest trimmed fat percentage was from pigs on diet 4 which had highly significantly lower trimmed fat percentage than those in diets 1 and 2 ($P < 0.01$) while the pigs on diet 5 also had significantly lower trimmed fat percentage than those on diets 1 and 2 ($P < 0.05$). The lowest percentage of dissected fat was also obtained from pigs on diet 4, which had significantly lower dissected fat than pigs on diet 1 ($P < 0.01$) and 2 and 5 ($P < 0.05$).

TABLE 5

Carcass Quality Measurements, Organ Weights and Dissected Tissue Percentages of Yorkshire Pigs fed Graded Levels of Cane Molasses

Characteristics	Treatment means					SE	Coefficient of variation, %
	1	2	3	4	5	Means	
Warm dressing percentage	73.89	73.14	72.16	72.49	71.79	0.316**	1.38
Average carcass length, cm.	68.44	69.77	70.44	69.94	69.97	0.359**	1.63
Average loin eye area, cm^2	16.46	17.03	17.03	17.81	17.40	0.740	13.65
Average back fat thickness, cm.	2.90	2.84	2.64	2.47	2.46	0.069**	8.23
Ham as percent chilled carcass	27.36	27.43	27.73	28.72	28.74	0.322*	3.64
Loin as percent chilled carcass	13.70	14.08	14.08	14.81	14.02	0.232*	5.16
Shoulder as percent chilled carcass	22.02	22.19	22.18	22.31	21.84	0.348	4.98
Average percent yield of lean cuts	63.50	63.54	64.34	65.84	64.56	0.596	2.93
Average percent fat cuts	23.17	23.90	24.30	23.67	23.81	0.302	4.01
Average percent trimmed fat	15.84	15.70	13.62	12.43	13.31	0.548**	12.21
Average percent dissected fat	29.63	28.88	28.16	25.40	28.62	0.778**	8.75
Average dissected lean, %	58.61	59.41	59.56	61.10	59.76	0.600	3.19
Average percent dissected bone	9.85	10.29	10.89	10.82	10.68	0.237*	7.12
Average gut weight, kg.	4.57	4.98	5.13	4.89	5.32	0.100*	6.31
Average fresh liver weight, kg.	1.41	1.60	1.65	1.72	1.77	0.036**	9.9
Average fresh kidney weight, kg.	0.25	0.32	0.32	0.34	0.38	0.005**	5.22
Average fresh heart weight, kg.	0.26	0.31	0.32	0.31	0.33	0.013**	13.63
Average abdominal fat weight.	1.06	1.13	1.108	0.74	0.88	0.071**	23.0

* = Significant treatment differences, ($P\% < 0.05$).
** = Highly significant treatment differences ($P < 0.01$).

With respect to the dissected bone, this also generally increased with increases in dietary molasses. Pigs on diet 1 had the lowest percentage which was significantly lower than the bone percentages for diets 3 and 4 ($P < 0.05$) which had the highest percentages.

Effects on Organ Weights

The treatment means of the organ weights are also shown in table 5. The liver weight was highly significantly inc reased by the increases in dietary molasses. The lowest weight recorded for pigs on diet 1 was highly significantly lower than the weights for pigs on diets 2, 3, 4, and 5 ($P < 0.01$), while pigs on diet 1 had significantly lower liverweight than those on diet 2 ($P < 0.05$). The average kidney weights followed the same trends as the liver weights. The lowest weight obtained from pigs on diet 1 was highly significantly lower than those on diets 2, 3, 4 and 5, ($P < 0.01$) while the pigs on diets 2 and 3 also had significantly lower kidney weights than those on diet 5 ($P < 0.01$).

The lowest average heart weight was also produced by pigs on diet 1, and their mean weight was significantly smaller than the average for pigs on diet 5 and 2, 3, 4 ($P < 0.05$). Although the trend with the spleen weight was like those of the liver, heart and kidneys, there were no significant increases in the spleen.

Finally, the abdominal fat was significantly reduced by dietary molasses levels. The lowest mean abdominal fat weight which was obtained from pigs on diet 4, was highly significantly lower than that for pigs on diet 2 ($P < 0.01$) and on diets 1 and 3 ($P < 0.05$).

Effects on Nutrient Utilization

The relevant treatment means appear in table 6. The apparent digestibility coefficients for the DM and nitrogen were remarkably similar for all treatments and were, therefore, not dependent on the levels of dietary molasses. The digestibility figures for the ether extract and NFE were also fairly similar for the treatment, but that of the crude fibre was significantly increased as the level of cane molasses increased, ranging from 47.4% for diet 1, to 65.3% for diet 5.

TABLE 6

Digestibility and Retention of Major Nutrients and the Energy Utilization by Pigs Fed Graded Levels of Cane Molasses

Items	*Treatment means*					*SE*
	1	2	3	4	5	*means*
Dietary level of molasses	0.0	10.0	20.0	30.0	40.0	—
Average daily DM intake, kg	1.43	1.44	1.60	1.55	1.75	0.04
Average daily N intake, g	52.7	53.0	57.1	61.6	71.7	0.58**
Average daily ether extract intake, g	44.4	47.0	43.0	45.5	45.3	0.61
Average daily crude fibre intake, g	57.5	80.1	94.0	112.3	131.4	0.98**
Average daily NFE intake, kg	0.91	0.90	0.95	0.88	0.97	0.03*
Apparent DM digestibility, %	85.3	85.9	86.4	86.0	83.3	0.65
Apparent digestibility of N, %	87.8	85.0	87.8	87.0	83.1	0.63
Apparent ether extract digestibility, %	69.0	68.4	72.3	74.3	71.5	0.61
Apparent digestibility of crude fibre, %	47.7	48.6	53.1	58.5	65.3	0.43**
Apparent NFE digestibility, %	85.5	85.2	84.3	84.5	82.7	0.52
N retained/$Wkg^{0.75}$	10.8	12.3	8.2	9.4	8.1	0.082*
Percent N intake retained	55.6	68.7	50.6	49.8	40.4	0.21**
Percent N digested retained	63.6	80.7	56.5	57.0	47.3	1.85**
Digestibility energy utilized, %	85.4	85.6	85.3	86.7	84.6	2.70
Metabolizable energy utilized, %	78.5	79.7	79.5	78.9	76.4	0.45
Gross energy value of the ration, kcal/100g	406	435	445	474	461	—
Digestible energy value of the ration kcal/100g	347	372	380	411	390	—
Metabolizable energy value, kcal/100g	319	347	354	374	352	—
Total Digestible Nutrients, %	82.0	81.0	79.0	79.0	76.5	—

* Significant difference ($P < 0.05$)
** Highly significant difference ($P < 0.01$)

With respect to the nitrogen retention, levels of molasses above 10% significantly decreased the nitrogen retention percentages, as well as the percent of digested N that was retained, (P <0.01) these two parameters being highest for the 10% molasses diet, and lowest for the 40% molasses diet. This was also the observation with the N retained/metabolic body size/day.

There were no significant differences in the percentages of DE and ME utilized the values being remarkably similar for all the treatments.

Effects on Production Costs

The relevant summaries appear in table 7, estimates which did not include the cost of labour that was difficult to assess, although this would be common to all treatments. The level of cane molasses sharply decreased the cost/metric ton of feed without sharply reducing the liveweight gains or increasing the volume of feed consumed. The result of these

TABLE 7

Comparative Estimates of the Costs of Production on each Diet-a/

Items	*Treatments* 1	2	3	4	5
Total feed consumed, kg	2035.3	2043.1	2045.4	2036.6	2184.6
Total liveweight gained, kg	572.5	595.6	596.6	595.9	598
Feed cost/metric ton, Naira	128.70	115.94	102.96	90.20	77.22
Cost of feed consumed, Naira	261.90	236.87	210.55	183.74	168.73
Gross revenue from pig sales, Naira	251.90	262.07	262.50	262.20	263.43
Gross revenue gained per treatment, Naira	-10.0	25.20	51.95	78.46	94.70
Feed cost/kg liveweight gained, Naira	0.46	0.40	0.35	0.31	0.28
Gross gain/feed cost, %	-3.82	10.64	24.67	42.70	56.13

-a/ Based on the current prices prevalent in the country at the time of experimentation. Labour cost was ignored for all the treatments.

combinations was that the gross revenue gained per treatment (total sales — feed cost) significantly increased as the level of cane molasses increased even up till the highest level of inclusion, while the feed cost/kg. liveweight gained correspondingly significantly reduced, and the gross gain expressed as percentage of the feed cost also sharply increased as the level of dietary molasses increased.

DISCUSSION

Despite the fact that the ADG figures for pigs in these investigations were not as high as those reported by other workers who have tested graded levels of molasses in pig diets (Blanco *et al.*, 1964; Iwanaga *et al.*, 1959; and Maner *et al.*, 1969), these studies have clearly shown that pigs in this area, particularly when reared to the growing-fattening stages, do tolerate high molasses diets much more than one had anticipated from past literature. The problem of soft or watery faeces was evident, but this did not appear to bother the pigs much because there were no correspondingly sharp decreases in the ADG. The slightly lower ADG values in these studies could have been caused by the slightly poorer quality of the protein in these diets since none of them contained fish meal and groundnut meal furnished most of the protein. It is significant to note that although there were decreases in the ADG as the dietary level of molasses exceeded 10%, the decreases were small and gradual, unlike the sharp, significant decreases reported by Blanco *et al*, (1964), Brooks and Iwanaga (1967), Iwanaga *et al,* (1959) and Maner *et al,* (1967). The plausible explanation for the gradual drop in ADG was the fact that we had earlier equalized the dietary protein levels by slight increases in the protein concentrates as the molasses displaced maize, and thus maintained fairly similar amino acid profiles for all diets. Unequal protein levels or very dissimilar amino acid values for the diets would very easily result in sharp differences in the ADG as those other workers reported. The results of the efficiencies of feed utilization are in good agreement with those reported by other workers in that the feed efficiency ratios tended to increase as the dietary molasses increased, but differed also in the absolute ratios which are smaller than the ratios they reported, and increased only gradually, unlike their sharp increases.

The carcass quality measurements have not usually been examined by previous workers and so comparisons are scarce. Nevertheless, the clear trends are better lean meat, smaller fat cuts, less trimmed fat, thinner back fat measurements, longer carcasses and generally meatier animals as the dietary levels of molasses increased. These could be explained from the fact that whereas the DM, energy, and hence air dry feeds consumed per pig per day tended to be uniformly close or slightly higher on high molasses diets, the utilisation of these feeds were slightly poorer for those pigs on high molasses diets, leading to higher wastage of energy that would have been used for fattening. Thus the pigs on high molasses diets apparently laid down smaller quantities of fat and correspondlingly leaner meat than those on low or no molasses diets.

The aspect of organ weights have not been covered by previous workers. The trend here was clearly increases in the weights of the livers, hearts and kidneys as the level of molasses increased, a finding which shows the significance of these organs, particularly the liver and the kidneys, in the metabolism of the excess sugar load presented to them through high molasses. The increase in heart weight was an indirect effect of the increases in the metabolic activities of the liver, while the lack of any significant changes in the spleen weight is also a reflection of the little connection of this organ in the metabolism of the sugars.

Of all the nutrients studied, only the crude fibre digestibility and nitrogen retention appeared to be significantly influenced by the dietary molasses levels. The crude fibre digestion coefficients were very clearly improved with increases in dietary molasses, and the picture presented is that of some enhancement of fibre utilization when molasses is present in the diet. An explanation for this phenomenon is difficult to find, since it is contrary to what normally happens with the ruminants in which the rumen micro-organisms preferentially break down the easily digestible sugars at the expense of the carbohydrates in the fibrous feeds. Perhaps the molasses sugars provided more readily utilized energy for the few cellulolytic microorganisms in the simple-stomached pigs which enabled them to act more on the fibre component of the feed. However the mechanism of such action, if it exists, is still difficult to envisage, and more work should be done on this aspect. The other significant finding in these studies is that of sharply decreased nitrogen retention figures despite the apparently high digestion coefficient for it. That it should so sharply decrease is a paradox despite the fact that attempts were made to equalize the quality of the dietary proteins for all the diets, but the osmotic effect of high molasses which led to the problem of fairly soft faeces might be connected with these decreases. These decreases in nitrogen retention figures would also partially explain the poorer efficiencies of feed utilization as the molasses levels increased. Apparently the degrees of utilization of the dietary metabolisable and digestible energies were not adversely affected.

Finally an analysis of the relative costs of production on the different diets presents interesting findings, and the obvious conclusion from these data is that the incorporation of molasses in pig diets helps considerably in reducing the cost of production and hence increases the gains in revenues from the enterprise. It is also clear from these data that even at 40% level of molasses, the point of diminishing returns in revenue gained had not been reached, and so it would appear that another step beyond 40% molasses might still prove rewarding financially, or it might be the point that diminishing returns begin to set in, but this is purely conjectural. While the net gain on this small scale experiment appears small, it should be borne in mind that adopting this system on very large scale operations should prove economically rewarding. One must also bear in mind that if the price of molasses should increase relative to other ingredients, the financial returns may not be so good, and in fact, the point of diminishing financial gains should certainly come up before the 40% level. However, although the financial considerations would certainly tempt one to use high level, of molasses in pig diets, its major problems should be weighed against advantages and these problems, apart from the commonly-mentioned diarrhoea, are the difficulties with mixing the very thick, viscous stuff with the rest of the ingredients, the problem of flies, and the rapid fermentation rate of the sugar in molasses in the tropical environment which may mean having to mix such diets very frequently, and keeping the bags in cool, fly-proof stores.

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