PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 5 (3): 242-247, 2006
ISSN 1680-5194

Performance, Cost Benefit, Carcass Quality and Organ Characteristics of Pigs Fed High Graded Levels of Brewers' Dried Grain Diets in the Humid Tropics

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Abstract: Twenty-four (Landrace x Large white) weaner pigs with average live weight of 6.36 kg (6.25-6.50 kg) were used to evaluate the performance, cost benefit, carcass quality and organ characteristics of pigs fed high graded levels of brewers' dried grain (BDG) diets in the humid tropics. The diets contained 0, 30, 35 and 40% BDG in Treatments 1, 2, 3 and 4, respectively. The experiment was in a completely randomized design (CRD) with each treatment replicated three times. Live weight, weight gain, feed and protein intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) were measured. Other measurements were feed cost of weight gain, gross margin, warm dressed weight, carcass and organ characteristics. Results showed that weaner pigs fed 40% BDG diet had significantly ($P<0.05$) higher protein intake (113.65 g) than others, while increasing levels of BDG in the diets significantly ($P<0.05$) decreased feed cost at the weaner stage. At the grower stage, pigs fed 35% BDG diet had weight gain, FCR and PER values similar to those fed control diet, while BDG diets significantly affected back fat (1^{st} rib) thickness, carcass length and percent spleen. It was concluded that weaner pigs could be fed 40% BDG diet to reduce feed cost, without adverse effect on growth performance. At the grower stage, the optimum inclusion level of BDG in the pig's diet should be 35%, although 40% BDG diet could be fed to reduce feed cost without adverse effect on carcass quality and organ characteristics of the pigs.

Key words: Brewers' dried grain, carcass quality, growth, pigs

Introduction

Brewers' dried grain (BDG) is solid waste from the brewery industries. It is available and cheap but difficult to dry to low moisture content for easy storage and use, especially during the wet seasons. There is wide variability in the proximate composition of BDG depending on the brewery that produced it (Oyediji, 2001). Breweries in Nigeria presently do not use barley or wheat to produce beer due to its importation and high cost. They mostly use maize and sorghum in combinations, which vary from one brewery to another (Oluponna *et al*., 2002). This, therefore, has resulted in the production of BDG with variable physical and chemical/proximate composition (Oluponna and Balogun, 1996).

BDG contains about 19–25% crude protein (Alawa and Umunna, 1993; Olomu, 1995; Kwari *et al*., 1999; Oluponna *et al*., 2002), 10–22% crude fibre (Olomu, 1995; Kwari *et al*., 1999; Oluponna *et al*., 2002), ME of 7.38 MJ/kg (Obioha, 1992) and gross energy value of 3030–3170 kcal/kg (Oluponna *et al*., 2002).

While the use of barley BDG in poultry feeding (Longe and Adetola, 1983; Dogari, 1985; Oluponna *et al*., 2002) is well documented, data on the utilization of maize/sorghum BDG by pigs are scanty. Kornegay (1973) had stated that, although 25 and 50% replacement levels could be recommended for good average daily gain of pigs, feed efficiency was depressed at the 50% replacement level. The inclusion of barley BDG at 15% of the diet for growing pigs did not depress growth rate, although, nutrient digestibility was lowered (Babatunde *et al*., 1975). Amaefule *et al*. (2006) had reported that pigs could be fed up to 40% BDG diets without adverse effect on nutrient digestibility and N retention. This study was, therefore, aimed at determining the performance; cost benefit, carcass quality and organ characteristics of pigs fed high graded levels of brewers' dried grain diets in the humid tropics.

Materials and Methods

Experimental pigs: Twenty-four hybrid (Landrace x Large White) weaner pigs were used in this experiment. They were 49 days old with an initial live weight that ranged from 6.25 to 6.50 kg (average 6.36 kg). They were made up of 12 females and 12 castrated males. Two pigs (castrated male and female) were placed in each pen.

Experimental diets: Four experimental diets were formulated with brewer's dried grain (BDG) as presented in Table 1. The inclusion levels of BDG were 0, 30, 35 and 40% in diets T1, T2, T3 and T4, respectively. Diet 1 (control) was maize-groundnut cake (GNC) based with no BDG while in the other diets, BDG replaced part of maize. All the diets were fortified with bone meal, salt and vitamin premix. The BDG was from Nigerian Breweries, Aba, Abia State, Nigeria.

Housing and management of pigs: The pigs were housed in a tropical-type and open-sided pig house roofed with asbestos roofing sheets. The open sides of the building were covered with expanded metal to prevent illegal entry of persons and iron net to prevent flies and other insects. Each pen which housed two pigs of a replicate measured 2.96 m x 3.95 m. The pens had a dwarf wall of 120 cm separating one from another and concrete floors. Each pen had a wallow (127 cm x 60 cm x 23 cm), feed (100 cm x 30 cm x 12 cm) and water (60 cm x 52 cm x 21 cm) troughs, all made of concrete, and a dunging area. The pigs were fed twice a day, in the morning (9.00-9.30 am) and afternoon (2.00-2.30 pm). Drinking water was provided *ad libitum* and there was water always in the wallowing trough for the pigs. The experimental diets were offered as dry mash.

The pigs were treated against ecto- and endo-parasites with Ivomectin^{R} injection prior to the start of the study. They were also given antibiotics (Tetracycline LA) injection to ensure good health.

Experimental design and data collection

Growth performance: The experimental design was completely randomized design (CRD). There were four treatments each replicated three times. Each replicate had two (castrated male and female) pigs. Data were collected for two growth stages: namely weaner and grower, although, there was no change in diets. The pigs were also not re-allocated. The weaner stage lasted 91 days while the grower stage lasted 85 days. Growth performance and cost benefit were evaluated at the weaner stage, while at the grower stage, carcass quality and organ characteristics were assessed at the end of the experiment.

The pigs were weighed at the start of the experiment and subsequently on a weekly basis. Weight gain was calculated as final live weight minus initial live weight. Feed intake was obtained as the difference between the quantity offered and quantity leftover (not consumed). Feed conversion ratio (FCR) was calculated as feed intake divided by weight gain.

Cost-bnefit: The cost per kg of the diet was calculated by multiplying the percentage composition of the feedstuffs with the price per kg of each feedstuff and summing all. Total feed intake x cost per kg feed gave total feed cost. Feed cost per kg weight gain was calculated as FCR x cost per kg of diet. Total feed cost was assumed to be 80% of total cost of production. Gross margin was calculated as price per kg pork minus total cost of producing 1 kg of pork.

Carcass quality evaluation: The castrated male pig from each replicate was used at the end of the experiment to evaluate the carcass quality and organ characteristic of pigs fed different levels of BDG diets. Prior to slaughter, the pigs were fasted for 16 hours but given drinking water. They were stunned with a metal rod and bled completely. Water (normal temperature) was poured on the entire skin surface and the hairs removed with a surgical blade. The head, trotters, tail, intestinal contents and organs were removed. The remaining carcass was weighed with a 100 kg capacity weighing Balance (Goat^{R} Brand) and expressed as a percentage of the live weight to obtain the warm dressing-out percentage. The fresh organs were also weighed using a sensitive top-loading balance (Aculab, 0.01g) and expressed as a percentage of the carcass weight. Abdominal fat was measured at the abdominal underlay and back fat thickness at the 1st and 4th ribs with Venier calipers. The carcass length was measured from the anterior edge of first rib to anterior edge of aitch bone.

Chemical and data analyses: Experimental diets and BDG were analyzed for proximate composition according to methods of A. O. A. C. (1990). Data on growth, live weight, and carcass quality and organ characteristics were subjected to analysis of variance (ANOVA) for CRD. The values in percentages were subjected to Arcsine transformation before ANOVA while differences among treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955). All statistical procedures were as outlined by Steel and Torrie (1980).

Results and Discussion

Weaner Stage

Performance: The performance of weaner pigs fed graded levels of brewer's dried grain (BDG) diets is presented in Table 3. The feeding of different levels of BDG diets to weaner pigs did not affect any performance criteria measured except protein intake. Among pigs fed BDG diets, daily protein intake significantly ($P<0.05$) increased with increase in the level of inclusion of BDG in the diets probably due to the increase in crude protein (CP) content of the diets with increase in the level of inclusion (Table 1). The difference between the pigs fed BDG and control diets in protein intake could also be attributed to differences in CP content (Table 2) of the diets since there were no significant differences in feed intake. Amaefule *et al.* (2006) had observed that differences in N intake of the pigs did not result in significant differences in N utilization suggesting that the differences in N intake were not biologically important.

The overall performance of the weaner pigs fed BDG diets could be considered impressive considering the fact that the diets had high crude fibre (CF) content, although it did not exceed 15%, the level above which feed intake (Braude, 1967) and growth rate (Stahly, 1984) are depressed. While the CP contents were within the range recommended by Holness (1991), Olomu (1995) and National Research Council (1998), the energy contents were lower, suggesting that microbial

Table 1: Percentage composition of diets of high graded levels of Brewers' dried grain

Feedstuffs	T1 (Control)	T 2	T 3	T 4
White maize	35.00	25.00	20.00	15.00
Groundnut cake (GNC)	20.00	10.00	10.00	10.00
Local fish meal	2.00	2.00	2.00	2.00
Brewers' dry grain	0.00	30.00	35.00	40.00
Maize offal	20.00	20.00	20.00	20.00
Wheat offal	19.00	9.00	9.00	9.00
Bone meal	3.50	3.50	3.50	3.50
Vitamin Premix*	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Total (%)	100	100	100	100
Calculated:				
CP (%)	18.65	18.25	18.80	19.35
ME (MJ/Kg)	11.44	11.69	11.39	11.08
CF (%)	4.34	8.79	9.69	10.59
Lysine (%)	0.56	0.71	0.75	0.78
Methionine (%)	0.28	0.31	0.32	0.33
Ca (%)	1.42	1.42	1.42	1.42
Avail. P (%)	0.59	0.59	0.59	0.59

*Contains per kg: Vit. A, 10000 IU; Vit. B, 2000 IU; Vit. E, 13000 IU; Vit.K, 1500 IU; Vit.B_{12}, 10 mg; Riboflavin, 5000 mg; Pyridoxine, 1300 mg; Panthotheinc acid,8000 mg; Nicotinic acid, 2800 mg; Folic acid,500 mg; Biotin, 40 mg; Copper,7.00 mg Manganese,48000 mg; Iron, 5800 mg; Zinc,58000 mg; Selenium,120 mg; Iodine,60 mg Cobalt,300 mg Choline,275,000 mg.

Table 2: Proximate composition of BDG and diets of high graded levels of BDG (% DM Basis)

Composition	0%	30%	35%	40%	BDG
Dry matter (%)	91.00	92.00	91.50	91.35	89.5
Crude protein (%)	20.91	22.75	20.43	21.66	22.49
Ether extract (%)	6.10	4.55	6.15	5.65	6.25
Crude fibre (%)	5.00	8.90	9.80	10.62	21
Ash (%)	7.80	8.45	8.30	8.10	4.7
Nitrogen Free Extract (%)	51.19	47.35	46.82	45.32	35.06

BDG = Brewers' dried grain.

fermentation in the large intestine may have contributed significantly in meeting the energy requirement of the pigs (Kennelly *et al.*, 1981).

Cost-benefit: There was significant reduction in total feed cost, feed cost per kg weight gain and total cost of production as a result of feeding different levels of BDG diets to weaner pigs (Table 4). This was in line with the earlier report of Babatunde *et al.* (1975) that BDG inclusion in pig's diet reduced feed cost. There was also an attendant significant (P<0.05) increase in financial benefits (gross margin) due to the feeding of different levels of BDG diets to weaner pigs as against the control diet. The diet containing 40% BDG significantly (P<0.05) reduced total feed cost more than any other BDG or control diet. In all cases, the feeding of 0% BDG (Control) diet resulted in significantly higher (P<0.05) costs than the BDG did.

It was observed that the lower total feed cost of 40% BDG diet did not result in lower feed cost per kg weight gain and increased gross margin, suggesting that there might not be increased financial benefit as a result of increasing the inclusion level of BDG in the diets above 35%. Therefore, to the pig farmer, the economic implication is that the optimum inclusion level of BDG in weaner pig diet is 35%, since cost minimization and gross margin are highest (numerically) at this level.

Grower stage

Performance: The performance of pigs fed different levels of BDG diets at the grower stage of life is presented in Table 5. Final live weight and daily feed intake did not significantly (P>0.05) differ between the pigs fed the control and BDG diets. Rather, 30% BDG diet significantly (P<0.05) reduced daily weight gain, daily protein intake and protein efficiency ratio (PER), and significantly (P<0.05) increased feed conversion ratio (FCR) of pigs when compared to the control and 35% diets. Pigs fed 35 and 40% BDG diets compared favourably with those fed control diet in all the performance parameters considered except daily protein intake. This may have been due to the fact that the diets had similar CP contents. Those fed control and 35% BDG diets had similar weight gain and FCR showing that the 35% BDG diet was as good as the control, while the lower weight gain and higher FCR for pigs fed 30 and 40% BDG diets clearly indicate that 35% was the optimum inclusion level, below or above which weight gain and FCR may be adversely affected. This result is supported by that of Kornegay (1973) who reported that, although 25 and 50% BDG could be recommended for good average daily gain, feed efficiency was depressed at the 50% inclusion level.

Table 3: Performance of weaner pigs fed high graded levels of BDG diets

Parameters	0%	30%	35%	40%	SEM
Initial live weight (kg/pig)	6.25	6.42	6.25	6.50	0.23
Final live weight (kg/pig)	19.25	19.00	20.08	19.33	0.75
Daily weight gain (g)	142.86	138.28	152.01	140.99	6.86
Daily feed intake (g)	587.36	584.06	584.06	587.36	2.33
FCR	4.1	4.27	3.87	4.20	0.21
Daily Protein intake (g)	109.54[b]	106.59[c]	109.80[b]	113.65[a]	0.43
PER	1.30	1.30	1.38	1.29	0.07

a, b Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard error of mean.

Table 4: Cost-Benefit of feeding high graded levels of BDG diets to weaner pigs

Cost	0%	30%	35%	40%	SEM
Cost per kg feed (N)	33.43	29.23	28.33	27.43	-
Total feed intake (kg)	54.45	53.82	54.45	54.45	0.32
Total weight gain (kg)	13.00	12.58	13.83	12.83	0.62
Total feed cost (N)	1820.26[a]	1573.06[b]	1542.57[c]	1493.56[d]	9.25
Cost per kg weight gain (N)	137.51[a]	124.81[ab]	109.54[b]	115.11[b]	6.00
Total cost of Production (N)	171.88[a]	156.01[ab]	136.93[b]	143.89[b]	7.50
Price per kg Pork (N)	250.00	250.00	250.00	250.00	-
Gross margin (N)	78.12[b]	93.99[ab]	113.07[a]	106.12[a]	7.50

a - d Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard error of mean. $1.00 = N147.00

Table 5: Performance of grower pigs fed high graded levels of BDG diets

Parameters	0%	30%	35%	40%	SEM
Initial live weight (kg/pig)	19.25	19.00	20.08	19.33	0.75
Final live weight (kg/pig)	35.92	33.42	36.92	34.42	1.20
Daily weight gain (g)	198.04[a]	169.61[b]	198.04[a]	177.45[ab]	6.08
Daily feed intake (g)	750.00	750.00	750.00	750.00	0.00
FCR	3.79[b]	4.44[a]	3.79[b]	4.24[ab]	0.14
Daily Protein intake (g)	139.88[c]	136.88[d]	141.00[b]	145.13[a]	0.00
PER	1.42[a]	1.24[b]	1.41[a]	1.22[b]	0.04

a - c Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard error of mean.

The results of this study are in line with those of Yaakugh and Tegbe (1990) with 30% BDG in 18% CP corn-soybean meal diet. They had reported that 30% BDG diet, which was their highest inclusion level, depressed growth performance of grower pigs. Our results, which are an improvement over those of Babatunde *et al.* (1975) with 15% BDG diet and Yaakugh and Tegbe (1990), have shown that grower pigs fed 35% BDG diet had the same growth rate (daily weight gain) and feed conversion ratio (Table 5) with those fed control (0% BDG) diet. This could be attributed to changes in the chemical and proximate composition of BDG with time associated with changes in brewing technology. However, final live weight, daily feed intake and daily weight gain were lower than those obtained by Ugwuene (2002) with maize-BDG mixture, probably due to longer period of the maize-BDG mixture study and differences in the hybrid of pigs used.

The pigs used in this study did not show any signs of amino acid deficiencies like reduced feed intake and general unthriftiness (National Research Council (NRC), 1998) despite the fact that the diets contained lysine, methionine and energy levels below the NRC (1998) recommended levels. Microbial fermentation in the hind gut, which is influenced by the amount and type of substrate (Jensen, 2001), may have compensated for the shortfall. This suggests that the requirements for the above and other nutrients by pigs in the humid tropics fed diets of mainly agro-industrial by-products may be different from the nutrient standards already set in the temperate and industrialized countries.

Cost-benefit: Cost-benefit analysis of feeding different levels of BDG diets to grower pigs is shown in Table 6. Increase in the inclusion levels of BDG from 30 to 40% resulted in non-significant (P>0.05) decrease in cost per kg of diet and significant decreases (P<0.05) in total feed cost. As expected, the control diet gave significantly (P<0.05) higher total feed cost, feed cost per kg weight gain and total cost of production than the BDG diets due to the higher cost per kg (N40) of maize against N22 for 1kg of BDG.

The diet of 35% BDG gave the highest profit, showing that it is more economical and beneficial to include BDG as 35% of the whole diet. This is similar to the results earlier obtained with weaner pigs and Babatunde *et al.* (1975), pointing out that irrespective of the stage of growth; it is more beneficial to include BDG at 35% level in pig diets.

Carcass quality and organ characteristics: The carcass quality of pigs fed different levels of BDG diets

Table 6: The cost-benefit of feeding high graded levels of BDG diets to grower pigs

Cost	0%	30%	35%	40%	SEM
Cost per kg feed (N)	33.43	29.23	28.33	27.43	-
Total feed intake (kg)	63.75	63.75	63.75	63.75	0.00
Total weight gain (kg)	16.83[a]	14.42[b]	16.83[a]	15.08[ab]	0.52
Total feed cost (N)	2131.16[a]	1854.41[b]	1806.04[c]	1748.66[d]	4.50
Cost per kg weight gain (N)	126.70[a]	129.68[a]	107.28[b]	116.21[ab]	4.18
Total cost of Production (N)	158.37[a]	162.11[a]	134.17[b]	145.26[ab]	5.22
Price per kg Pork (N)	250.00	250.00	250.00	250.00	-
Gross margin (N)	91.63[b]	87.89[b]	115.83[a]	104.73[ab]	5.22

[a-d]Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard error of mean. $1.00 = N147.00

Table 7: Carcass Quality and Organ characteristics of Pigs fed high graded levels of BDG diets

Parameters	0%	30%	35%	40%	SEM
Dressed Weight (%)	57.54	58.43	56.67	58.72	0.84
Ham (%)	36.23	37.38	39.3	36.12	0.55
Fore arm (%)	36.87	37.23	41.45	37.66	0.27
Loin (%)	7.73	6.17	6.53	6.47	0.68
Rib cage region (%)	20.62	21.1	17.01	20.8	0.85
Head (%)	17.1	19.15	19.75	18.38	0.48
Trotters (%)	4.16	3.75	4.48	3.96	0.38
Tail (%)	0.49	0.58	0.62	0.39	0.46
Back fat thickness					
1st Rib (cm)	1.83[a]	1.67[ab]	1.25[b]	1.93[a]	0.14
4th Rib (cm)	1.33	1.17	1.27	0.77	0.18
Carcass length (cm)	84.78[a]	74.17[a]	63.08[b]	74.13[a]	3.26
Heart (%)	0.7	0.84	0.95	1.15	0.41
Liver (%)	3.88	3.75	4.07	3.29	0.37
Lungs (%)	1.65	1.71	1.79	1.56	0.21
Kidney (%)	0.34	0.52	0.63	0.58	0.29
Spleen (%)	0.21[b]	0.43[a]	0.42[a]	0.48[a]	0.27
Empty Stomach (%)	1.74	1.71	1.96	2.07	0.36
Small Intestine (%)	4.01	4.71	4.63	5	0.26
Large Intestine (%)	3.02	2.57	3.42	2.91	0.49

[a,b]Means in a row with different superscripts are significantly different (P<0.05). SEM = Standard error of mean.

(Table 7) did not differ significantly (P>0.05) among each other. The exceptions here were back fat (1st rib) thickness and carcass length.

Pigs fed 35% BDG diet had significantly lower (P<0.05) back fat (1st rib) thickness than those fed 40% BDG and control diets. This suggests that the pigs used much of their feed energy for muscle tissue accretion rather than fat deposition. The differences in carcass length may have been due to individual differences among the pigs. Organ characteristics did not also differ significantly (P>0.05) among the pigs fed the treatment diets. The exception was the spleen in which pigs fed the control diet had significantly lower (P<0.05) value than others. Pigs fed BDG diets did not differ among each other in all the organ characteristics.

Although, the carcass quality and organ characteristics obtained in this study could not be attributed to any factor, they are in line with those reported by Obioha and Anikwe (1982) with ensiled and sun dried cassava peel diets. The results equally confirm the reports of Babatunde *et al.* (1975) and Yaakugh and Tegbe (1990) that BDG diets did not affect carcass quality of hybrid pigs kept in the humid tropics.

Conclusion: Pigs in the humid tropics could fed 40% brewers' dried grain (BDG) diet to reduce feed cost at the weaner stage of life. At the grower stage, the optimum inclusion level of BDG in the pig's diet should be 35%, although 40% BDG diet could also be fed to reduce feed cost without adverse effect on carcass quality and organ characteristics.

Acknowledgement

The provision of pigs, equipment and support staff used for this study by Michael Okpara University of Agriculture, Umudike through Senate Research Grant is highly appreciated. We also thank Mr. Friday Eluwa and Victor Ukaonu for their hard work and dedication throughout the period of the study.

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