

A COMPARISON BETWEEN SOYBEAN MEAL, FISHMEAL AND WHALE SOLUBLES IN ISONITROGENOUS BARLEY AND SORGHUM GRAIN BASED DIETS FOR GROWING PIGS

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Summary

In a factorial experiment, 48 crossbred pigs were restrictively and individually fed from 18.4 to 81.2 kg liveweight isonitrogenous diets based on barley and sorghum, each supplemented with four protein concentrates (soybean meal, fishmeal, whale solubles and soybean meal plus whale solubles).

Barley diets gave more efficient energy utilisation in all growth periods, better feed conversion ratios in the period to 50 kg liveweight, and resulted in leaner carcasses with higher eye muscle indices than sorghum diets.

Significant differences between protein concentrates were recorded for feed and energy utilisation in the period to 50 kg liveweight, with diminished differences in the subsequent growth period. Eye muscle index was the only carcass parameter significantly affected by protein concentrate source.

A significant grain x protein concentrate interaction was evident for energy and feed conversion, there being less differences between protein concentrates when combined with barley than with sorghum.

These results are discussed in relation to lysine and tryptophan levels supplied in the diet, and their inter-relationships with energy intake

I. INTRODUCTION

The price of feed grains varies markedly depending on their availability. To take maximum advantage of these fluctuations, determination of the relative nutritive value of grains is essential. As grains are the major source of energy and contribute significant amounts of protein in swine diets, differences in growth performance between grains is therefore most likely due to the quantity or quality of protein or energy provided.

Barley and sorghum are widely used in pig diets in Australia, yet comparative studies are few (Beames and Sewell 1969). The lower digestible energy value of barley compared with sorghum (Robinson, Prescott and Lewis 1965; Lawrence 1967, 1968) could be offset by its better essential amino acid profile (National Research Council 1968; Harvey 1970).

This paper reports an experiment comparing the growth response and carcass characteristics of pigs restrictively fed isonitrogenous barley and sorghum diets of determined amino acid composition.

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II. MATERIALS AND METHODS

(a) *Animals and location*

24 gilt and 24 barrow Large White x Berkshire pigs, 9 weeks old and 18.4 kg \pm SD 1.3 kg liveweight were used.

The experiment was conducted at the Regional Research Station, Warwick, Queensland from August to December 1970.

(b) *Design and statistical analyses*

A 2 x 4 x 2 factorial experiment was used, the variables being grain type (80 per cent barley or 80 per cent sorghum), protein concentrates (12.5 per cent soybean meal, 9.5 per cent fishmeal, 6.7 per cent whale solubles or 6.25 per cent soybean meal plus 3.35 per cent whale solubles) and sex (gilt or barrow). Within each sex, pigs were stratified into 3 groups of 8 on the basis of liveweight and litter of origin. Within each group, pigs were then randomly allocated to the 8 diets.

The data were subjected to conventional analysis of variance. Growth rates and efficiencies of feed and energy conversion were analysed in 2 periods (a) "grower" 18.4 to 50.2 kg liveweight and (b) "finisher" 50.2 to 81.2 kg liveweight, as well as for the entire experimental period.

(c) *Experimental diets and feed analyses*

Consignments of barley (*Hordeum vulgare* var. Prior) and sorghum (*Sorghum vulgare* var. predominantly Texas 6 10) were individually blended to obtain grains of 13 per cent protein. Each diet contained either 80 per cent barley or sorghum grain and a protein concentrate supplying 35 per cent of the dietary crude protein (Table 1). Sufficient sago (87.2 per cent dry matter, predominantly carbohydrate) was added so that with the protein concentrate these two constituents made up 16.75 per cent of the diet. The remaining 3.25 per cent of the diet was a vitamin and trace element mix supplying per kg diet: Na Cl, 5 g; hydrated CaHPO_4 , 15 g; CaCO_3 , 7.5 g; vitamin A, 3,250 I.U.; vitamin D_3 , 400 I.U.; thiamin, 1.5 mg; riboflavin, 3 mg; nicotinic acid, 20 mg; calcium-D-pantothenate, 15 mg; vitamin B_{12} , 15 μg ; choline, 500 mg; Zn, 200 mg as ZnO; Fe, 100 mg as FeO; Mn, 30 mg as $\text{MnSO}_4 \cdot \text{H}_2\text{O}$; Co, 1 mg as CoCO_3 and K, 0.5 mg as KI.

The digestible energy (kJ/g) values used in computing the dietary levels in Table 1 were: barley 12.09; sorghum 13.81 (Robinson, Prescott and Lewis 1965); soybean meal 13.81; fishmeal 12.53 (National Research Council 1968); whale solubles 13.40 (estimated) and sago 16.57 (K. C. Williams — unpublished data). The levels of cystine (per cent) and tryptophan (per cent) were respectively: barley 0.18, 0.18; sorghum 0.18, 0.09; soybean meal 0.60, 0.60 (National Research Council 1968); fishmeal 0.57, 0.71 (G. M. Dreosti — personal communication); whale solubles 0.86, 0.40 (A. C. Jennings—personal communication) and sago 0, 0.

Proximate analyses of feeds were determined according to the procedures described by Connor, Neill and Burton (1971). The amino acids were determined on a Beckman 120 C amino acid analyser after hydrolysis with 6 N HCl at 110°C for 18 hours under sealed tube or reflux conditions. Only the limiting amino acids are presented (Table 1). All other essential amino acids were supplied at levels above those recommended by the National Research Council (1968)‘.

(d) *Management and recording*

Pigs received two equal feeds daily for the first 5 weeks, and then were fed

TABLE 1

Dry matter, crude protein, amino acid and digestible energy contents of the major dietary constituents

As per cent of diet

Attribute	Grains*		Protein concentrates*				Recommended levels‡
	Barley	Sorghum	Soybean meal	Fishmeal	Whale solubles	Soybean meal + whale solubles	
Inclusion level	80	80	12.5	9.5	6.7	9.6	—
Dry matter inclusion level	71.8	69.6	15.0†	14.8†	15.1†	15.0†	—
Crude protein	10.6	10.6	6.3	6.0	6.0	6.1	16
Lysine	0.34	0.20	0.43	0.53	0.42	0.43	0.7
Methionine	0.13	0.13	0.09	0.18	0.07	0.08	0.5
Cystine§	0.14	0.14	0.08	0.05	0.06	0.08	0.5
Tryptophan§	0.14	0.07	0.08	0.07	0.03	0.06	0.13
Digestible energy (kJ/100 g)§	967	1,105	243†	239†	257†	250†	1,381

* The total percentage of any attribute for each diet is given by adding the values in the respective grain and protein concentrate columns.

† Sago contribution included.

‡ For pigs 20-35 kg liveweight (National Research Council 1968).

§ Estimated data used in computing these are given in text.

TABLE 2

Average daily gains, feed and energy conversion ratios and carcass measurements for grain and protein concentrate comparisons

Parameters measured	Grain		Protein concentrate				± SE*
	Barley	Sorghum	SBM	FM	WS	SBM + WS	
Average daily gain (g/day)							
18.4 — 50.2 kg	428a†	340b	431b†	456a	366d	400c	5.2
50.2 — 81.2 kg	520a	529a	538a	546a	489b	525a	11.4
18.4 — 81.2 kg	469a	452b	479a	496a	414c	453b	4.4
Feed conversion ratio (g feed/g gain)							
18.4 — 50.2 kg	2.82a	3.04b	2.78b	2.65a	3.30d	2.99c	0.06
50.2 — 81.2 kg	3.37a	3.33a	3.25a	3.21a	3.59b	3.35a	0.10
18.4 — 81.2 kg	3.09a	3.18a	3.01a	2.93a	3.44c	3.17b	0.06
Energy conversion ratio (kJ DE/g gain)							
18.4 — 50.2 kg	34.27a	41.06b	35.56b	33.83a	42.82d	38.45c	0.71
50.2 — 81.2 kg	40.74a	45.01b	41.49a	40.88a	46.25b	42.89a	1.30
18.4 — 81.2 kg	37.48a	42.96b	38.53a	37.30a	44.39c	40.67b	0.76
Eye muscle index (mm ²)	3798a	3504b	3827ab	3973a	3231c	3574b	162
Backfat (mm)	18.1a	21.0b	18.1a	18.8a	21.5a	19.7a	1.6

SBM — Soybean meal. FM — Fishmeal. WS — Whale solubles.

* Average standard error of the 8 diet means.

† Within treatment comparisons, means containing a common letter are not significantly different from each other. $P < 0.05$.

once daily. Up to 20 kg liveweight, 0.9 kg daily was fed. For each 5 kg liveweight increase after this, the quantity was increased by 0.1 kg/day to 35 kg liveweight, then by 0.15 kg/day to 50 kg liveweight. A daily feed intake of 1.75 kg was then maintained for the duration of the experiment. The diets were fed moistened. The pigs were weighed weekly and the feed allowance for the following week determined from each weekly liveweight. Pigs were slaughtered 28 to 30 hours after the first weighing that their liveweight attained or exceeded 80 kg. Carcass **backfat** and eye muscle index measurements were determined by the method of Bostock (1964).

III. RESULTS

Average daily- gains, feed and energy conversion ratios and carcass measurements of grain and protein concentrate comparisons are given in Table 2. Dressing percentage ranged between 74.6 and 76.7 per cent (mean $75.5 \pm \text{SE } 0.8$) and was unaffected by dietary treatments.

The daily gains and feed conversion ratios of pigs fed barley were significantly superior ($P < 0.05$) to those of pigs fed sorghum only in the period 18.4 to 50.2 kg. However the energy conversion ratio was significantly better ($P < 0.05$) for the barley fed pigs in both periods. The feeding of barley resulted in carcasses with significantly greater ($P < 0.05$) eye muscle indices and less ($P < 0.05$) **backfat** than the feeding of sorghum.

Each protein concentrate resulted in daily gains and feed and energy conversion ratios significantly different ($P < 0.05$) from each other in the period 18.4 to 50.2 kg. The order, in descending superiority was fishmeal, soybean meal, combined soybean meal-whale solubles and whale solubles. These differences were diminished in the subsequent 50.2 - 81.2 kg period and overall. Superiority in growth performance between protein concentrates was associated in the carcass with superior ($P < 0.05$) eye muscle indices.

A significant ($P < 0.05$) grain x protein concentrate interaction occurred in all growth periods for daily gains and feed and energy conversion ratios, there being less difference in the performance of pigs between the protein concentrates when fed barley diets than sorghum diets. The overall average daily gain (g/day) and feed conversion ratio for the protein concentrates soybean meal, fishmeal, whale solubles and combined soybean meal plus whale solubles in barley diets were 485, 3.00; 481, 3.03; 441, 3.27 and 469, 3.09 respectively, and in sorghum diets 473, 3.03; 511, 2.83; 387, 3.60 and 437, 3.25 respectively (LSD at 5 per cent level = 25.4, 0.17). Similarly the overall energy conversion ratios were 36.26, 36.55, 39.70, 37.43 and 40.81, 38.05, 49.08 and 43.90 (LSD at 5 per cent level = 2.19).

Differences between sexes ($P < 0.05$) were limited to the 18.4 to 50.2 kg period where feed and energy conversion ratios were lower (2.86 v. 3.01 and 36.72 v. 38.61 respectively) and weight gains higher (423 v. 404) for barrows than for gilts.

IV. DISCUSSION

As the barley diets contained less energy than the isonitrogenous sorghum diets, the superior performance of the barley diets would appear to be due to the differential levels of essential amino acids. Similarly the differences in performance

between the protein concentrates would be due to the levels of essential amino acids. The reduction in these differences with increasing liveweight in accordance with the pigs reducing amino acid requirement (Costain and Morgan 1961; Bellis 1961; National Research Council 1968) also supports this hypothesis.

The comparable levels of methionine (plus cystine) supplied by sorghum and barley suggest that methionine was not limiting performance. This agrees with the findings of Beames and Pepper (1969) where no response was obtained to supplemental methionine in sorghum and wheat diets. The addition of choline in the diet would also reduce the requirement of sulphur containing amino acids. Lysine deficiency in diets based on sorghum grain, and protein concentrates other than fishmeal, and tryptophan deficiency in diets of sorghum and whale solubles could account for the observed differences between the dietary treatments.

Where amino acid levels were not limiting, differences in productivity could be attributed to the higher digestible energy of sorghum grain. Robinson, Morgan and Lewis (1964), Robinson and Lewis (1964) and Dent *et al.* (1970) found that an improvement in growth rate accompanied an increase in energy intake where pigs were fed to a restricted feeding scale.

The increased backfat coverage and reduced eye muscle indices observed for carcasses of pigs fed sorghum is similar to that reported by Robinson, Prescott and Lewis (1965), Lawrence (1967, 1968) and Beames and Sewell (1969). In these studies cited, pigs were restrictively fed, and in each instance the efficiency of conversion of energy was less for sorghum than barley. In contrast, Cole, Clent and Luscombe (1969) found no significant differences in carcass parameters between pigs fed barley or sorghum diets *ad lib.* Hays, Wagner and Clark (1963) and Clawson (1967) have shown that pigs fed *ad lib.* can maintain efficiency of energy conversion relatively independent of dietary crude protein levels and energy content by the voluntary adjustment in energy intake. However, where pigs are restrictively fed diets of different energy content, carcasses would only be similar where the efficiency of energy conversion resulted in similar levels of utilisable energy.

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