A COMPARISON OF THE DIGESTIBILITY OF WHEAT AND SORGHUM BY PIGS

By R. M. BEAMES, M.Agr.Sc.*

SUMMARY

A comparison was made between the digestibility of wheat and sorghum by pigs using three different methods of ration formulation, viz. grain alone, grain plus meatmeal, and grain plus skim-milk powder. For each type of ration, comparisons were made over the three body-weight ranges of 40-80 lb, 80-120 lb and 120-220 lb.

Dry-matter and organic-matter digestibilities in the wheat rations were either slightly higher than or equal to these values in the corresponding sorghum ration. The sorghum rations had a correspondingly small advantage in the digestibility of nitrogen-free-extract.

The major differences between the grains were in the digestibility of crude protein and crude fibre. Over all the body-weight ranges for all ration formulations the digestibility of the crude protein in the wheat ration was greater than that in the sorghum ration. The mean crude protein digestibility coefficients for the wheat and sorghum rations respectively were 92.3 and 72.2 for the grain-only rations, 89.6 and 77.9 for the grain plus meatmeal rations and 93.7 and 78.4 for the rations containing skim-milk powder.

Differences in digestibility of crude fibre were even more marked, the levels being much greater in the sorghum rations. Mean coefficients for the wheat and sorghum rations respectively were 31.6 and 75.6 for the grain-only rations, 27.2 and 81.6 for the rations containing meatmeal, and 22.9 and 69.6 for the grain plus skim-milk rations.

I. INTRODUCTION

Since 1939, the production of sorghum grain in Australia has risen from 58,000 bus to an estimated 7·5 million bus for 1962-63, with approximately 95 per cent. of this grain grown in Queensland. Provided suitable markets are found, a rapid rate of expansion of production should continue. Because of the high efficiency of utilization of grain by pigs in comparison with ruminants (Leitch and Godden 1953), an increase in pig production could well be associated with increased sorghum production.

Work done in the United Kingdom on Queensland sorghum of unnamed variety showed it to be well utilized at a 60 per cent. level in the ration (Braude and Mitchell 1950). A comprehensive review of the literature from the United States of America on the feeding of sorghum to pigs has been made by Tanksley

*Husbandry Officer, Animal Research Institute, Yeerongpilly. (Queensland Department of Agriculture and Stock)

(1961), who summarized results from the Agricultural Experiment Stations of Arkansas, Colorado, Illinois, Mississippi, Nebraska, Oklahoma and Texas. These results gave sorghum a mean value of 91·3 per cent. of corn when compared on the basis of feed conversion ratios, although in some cases sorghum when fed free choice produced an equal or greater rate of gain (Fletcher 1953; Aubel 1959). As the above data on the feeding value of sorghum were obtained in pens, no explanation for the variation in efficiency of utilization was possible.

The experiments reported below were done to compare the digestibility of sorghum with that of wheat, another grain used widely in rations for pigs in Queensland. Digestibility data were obtained on the grains when fed without supplements and with supplements of meatmeal and skim-milk powder.

II. MATERIALS AND METHODS

(i) *Animals.*—All pigs were Large White castrate males, obtained when 6-7 weeks of age and ranging in body-weight from 15 to 26 lb.

(ii) *Pre-experimental Treatment.*—On arrival the pigs were fed a ration of the following percentage composition:—Meatmeal 15, skim-milk powder 50, maizemeal 15, pollard 5, sugar 10, linseed oil 5 and salt 0·5. Aureomycin (as "Aurofac 2A", 3·6 g chlortetracycline hydrochloride per lb, American Cyanamid Company) was added at the level of 1·8 g/100 lb.

This ration was gradually changed so that the experimental rations were being fed by the time pigs reached a body-weight of 40 lb. During this pre-experimental period all pigs were treated with piperazine adipate on each of two occasions 3 weeks apart, and sprayed once with benzene hexachloride.

(iii) *Animal Management.*—At a body-weight of 40 lb the animals were accustomed to the metabolism units described by Beames (1962). On most occasions pigs were removed from the units and fed the appropriate ration in pens for 3-4 days between 12-day digestibility periods. On occasions where the ration promoted rapid growth, the rest period was omitted without apparent adverse effects on the pigs.

(iv) *Method of Feeding.*—The daily ration was divided into two equal feeds which were presented at 9.30 a.m. and 3.30 p.m. As no water was available at feeding time the feed was moistened with approximately 75 per cent. of its weight of water to encourage complete consumption. Any feed remaining 30 min after presentation was removed for analysis and the feed trough filled with water.

(v) *Analytical Methods and Techniques.*—Methods used in analyses of feed and faeces were essentially those of the Association of Official Agricultural Chemists (1955). A set of soil sieves was used to determine particle size of the grain.

(vi) *Ration Components.*—The sorghum was Martin variety; the two batches of wheat, one from Queensland and the other from Victoria, were of unknown variety. All grain was crushed by passing twice through a roller mill. The meatmeal was treated with butylated hydroxy-toluene (as "Ionol", supplied by Shell Chemical (Australia) Pty. Ltd.) prior to commencement of the experiments. The skim-milk powder was roller dried.

III. EXPERIMENTAL

The digestibility of wheat and sorghum was compared in three different ration types—grain alone (Experiment I), grain plus meatmeal (Experiment II) and grain plus skim-milk powder (Experiment III). Minerals and vitamins were added to each ration.

Two batches of wheat were mixed in order to obtain a crude protein content in the wheat comparable with that of the sorghum. Within each ration type, comparisons were made over three body-weight ranges, 40-80 lb, 80-120 lb and 120-220 lb. Each body-weight range was divided into two periods. In the first period two pigs were fed the sorghum ration and two the wheat ration. In the second period the treatments were reversed. Respective air-dry feed presentations over the 40-80-lb, 80-120-lb and 120-220-lb body-weight ranges were 1020 g, 2040 g and 2270 g for the unsupplemented grain rations and 900 g, 1800 g and 2700 g for rations containing meatmeal and skim-milk powder.

The pre-collection and collection periods of each digestibility measurement were 5 and 7 days respectively. Ration formulations are given in Table 1.

TABLE 1

FORMULATION OF RATIONS USED IN EXPERIMENTS I, II AND III

Component	Experiment I		Experiment II		Experiment III	
	Grain Ration		Grain and Meatmeal Ration		Grain and Skim-milk Powder Ration	
	Sorghum (%)	Wheat (%)	Sorghum (%)	Wheat (%)	Sorghum (%)	Wheat (%)
Sorghum	97·5	..	90	..	80·64	..
Wheat	..	97·5	..	90	..	80·25
Meatmeal	..	..	10	10	..	..
Skim-milk powder	..	..	..	..	17·91	18·31
Salt	0·5	0·5	..	..	0·44	0·45
Tricalcium phosphate	2·0	2·0	..	..	0·96	0·99
Limestone	..	..	..	..	0·05	..
Riboflavine	0·2g/100 lb	0·2g/100 lb	..	..	..	..

Stabilized vitamins A and D were added to all rations at the levels of 2000 I.U. and 400 I.U./lb respectively

IV. RESULTS

(i) *Feed Analyses.*—Analyses of rations and ration components are presented in Table 2. Determination of particle size showed that 74 per cent. of the crushed wheat and 82 per cent. of the crushed sorghum was within the range 1·02 to 2·41 mm in diameter.

TABLE 2

PROXIMATE ANALYSES OF RATIONS AND RATION COMPONENTS IN EXPERIMENTS I, II AND III

—	Moisture (%)	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	N.F.E. (%)	Ash (%)	Ca (%)	P (%)
Ration Components—								
Queensland wheat	11·7	14·9	2·1	2·4	67·2	1·7	0·06	0·36
..	*16·9*	*2·4*	*2·7*	*76·1*	*1·9*	*0·07*	*0·41*	
Victorian wheat	11·2	9·8	1·9	2·7	73·0	1·4	0·05	0·25
..	*11·1*	*2·1*	*3·0*	*82·2*	*1·6*	*0·06*	*0·27*	
Sorghum	12·3	14·1	3·1	1·9	67·2	1·4	0·05	0·38
..	*16·1*	*3·5*	*2·2*	*76·6*	*1·6*	*0·06*	*0·34*	
Meatmeal	7·1	54·2	9·4	..	6·6	22·7	7·43	3·67
..	*58·3*	*10·1*	..	*7·1*	*24·4*	*8·00*	*3·93*	
Skim-milk powder	9·5	32·9	0·3	..	50·1	7·2	1·50	0·87
..	*36·3*	*0·3*	..	*55·5*	*7·9*	*1·64*	*0·96*	
Experiment I—								
Sorghum ration	11·7	14·3	1·9	2·7	66·0	3·4	0·44	0·58
..	*16·2*	*2·2*	*3·0*	*74·7*	*3·9*	*0·50*	*0·66*	
Wheat ration	11·2	13·9	0·9	2·1	68·3	3·6	0·51	0·51
..	*15·6*	*1·0*	*2·4*	*76·9*	*4·1*	*0·57*	*0·57*	
Experiment II—								
Sorghum and meatmeal ration	10·6	18·2	3·1	2·7	61·7	3·7	0·69	0·71
..	*20·4*	*3·5*	*3·0*	*69·0*	*4·1*	*0·77*	*0·79*	
Wheat and meatmeal ration	8·1	18·3	2·4	2·2	65·4	3·6	0·71	0·69
..	*19·9*	*2·6*	*2·4*	*71·2*	*3·9*	*0·77*	*0·75*	
Experiment III—								
Sorghum and skim-milk powder ration	12·0	17·5	2·3	1·8	62·7	3·8	0·70	0·62
..	*19·9*	*2·6*	*2·0*	*71·2*	*4·3*	*0·80*	*0·70*	
Wheat and skim-milk powder ration	10·1	17·9	1·3	2·0	65·0	3·8	0·70	0·62
..	*19·9*	*1·4*	*2·2*	*72·3*	*4·2*	*0·80*	*0·70*	

Figures in italics are expressed on a dry-matter basis

(ii) *Digestibility Data.*—The digestibility coefficients of wheat and sorghum when fed with no supplement, with a supplement of meatmeal and with a supplement of skim-milk powder are presented in Table 3. These results are presented for the three body-weight ranges of 40-80 lb, 80-120 lb and 120-220 lb.

TABLE 3

MEAN DIGESTIBILITY DATA IN EXPERIMENTS I, II AND III

Experiment	Ration	Body-weight Range (lb)	Mean Daily D.M. Intake (g)	Digestibility Coefficients				
				Dry Matter	Organic Matter	Crude Protein	N.F.E.	Crude Fibre
I	Wheat	40–80	858	89·0*	90·4*	91·0***	93·1	32·0
		80–120	1804	89·8*	91·4*	93·0***	93·7	24·7
		120–220	1928	89·2*	90·6*	92·8***	93·0	37·9
	Mean ..	40–220	1530	89·3*	90·8*	92·3***	93·3	31·6
	Sorghum ..	40–80	833	87·0	88·9	73·8	94·6**	70·8***
		80–120	1496	87·9	89·8	72·3	95·8**	78·5***
		120–220	1509	87·2	89·1	70·5	95·5**	77·5***
	Mean ..	40–220	1279	87·4	89·3	72·2	95·3**	75·6***
	Standard error	..	..	± 0·80	± 0·70	± 1·7	± 0·37	± 4·4
II	Wheat and meat-meal	40–80	798	87·7	89·4	90·1***	92·1	22·2
		80–120	1537	88·0*	89·7*	88·5***	92·7	26·9
		120–220	2206	87·3	89·1*	90·2***	91·4	32·4
	Mean ..	40–220	1514	87·7	89·4	89·6***	92·1	27·2
	Sorghum and meatmeal	40–80	727	87·9†	89·7†	81·8‡	93·7***	87·7**
		80–120	1509	86·8	88·5	75·8	94·6***	76·0**
		120–220	2208	87·1	88·7	76·0	94·2***	81·1***
	Mean ..	40–220	1481	87·3	89·0	77·9	94·2***	81·6***
	Standard error	..	..	± 0·19	± 0·14	± 0·59	± 0·26	± 3·5
III	Wheat and skim-milk powder	40–80	816	90·0	91·2	92·2***	94·0	19·4
		80–120	1616	90·8	91·7	94·3***	94·3	20·7
		120–220	2419	90·9	92·4	94·5***	94·9	28·6
	Mean ..	40–220	1617	90·6	91·7	93·7***	94·4	22·9
	Sorghum and skim-milk powder	40–80	819	88·1	89·4	74·0	94·8*	63·7**
		80–120	1636	90·0	91·2	80·4	96·2*	73·2**
		120–220	2405	90·0	91·4	80·7	97·0*	72·0**
	Mean ..	40–220	1620	89·4	90·7	78·4	96·0*	69·6**
	Standard error	40–80	..	± 0·94	± 0·92	± 1·8	± 0·4	± 5·9
		80–220	..	± 0·94	± 0·92	± 1·8	± 0·5	± 8·4

*, **, *** greater than corresponding level in other ration within same experiment (*P<0·05; **P<0·01; ***P<0·001)

†, ‡ greater than corresponding values for the other two body-weight ranges within the same ration (†P<0·05; ‡P<0·01)

Within experiments, differences in digestibility between age groups were evident only with the sorghum plus meatmeal ration in Experiment II. Here, the digestibility of dry matter, organic matter and crude protein in the 40-80-lb body-weight range was significantly better than in the other two weight ranges. These

differences were small, however, except in the case of protein, where the comparative digestibility coefficients in the 40-80, 80-120 and 120-220-lb body-weight ranges were 81·8, 75·8 and 76·0 respectively.

Comparisons of digestibility between wheat and sorghum rations showed a consistent pattern in each of the three experiments.

Differences in the digestibility of dry matter and organic matter were small, but a significant difference in favour of the wheat rations was obtained in some body-weight ranges.

A marked difference between the sorghum and wheat rations occurred in the apparent digestibility of crude protein. In each experiment for all body-weight ranges the digestibility of the protein in wheat rations was significantly better than that of the protein in sorghum rations ($P < 0{\cdot}001$). Respective mean digestibilities of protein in the wheat and sorghum rations were 92·3 and 72·2 per cent. in Experiment I, 89·6 and 77·9 per cent. in Experiment II and 93·7 and 78·4 per cent. in Experiment III.

In each experiment for all weight ranges digestibility of the fibre in the sorghum ration was greater than in the wheat ration ($P < 0{\cdot}001$, $P < 0{\cdot}001$ and $P < 0{\cdot}01$ in Experiments I, II and III respectively). Over all experiments mean fibre digestibilities in the sorghum and wheat rations were 75·6 and 26·1 per cent. respectively, with that of the sorghum ration never less than 63·7 and that of the wheat ration never greater than 37·9.

(iii) *Observations on Feeding.*—Throughout the whole of this study the feed consumption rate of the animals receiving sorghum was markedly less than that of the animals receiving wheat. However, due to the 30-min limitation on time of feeding, differences in intake were minimized during digestibility periods.

V. DISCUSSION

The three methods of feeding grain in this experiment—alone, with meatmeal, and with skim-milk powder—were used in order to determine the influence of supplements on the comparative digestibilities of wheat and sorghum. Little significance can be attached to comparisons between experiments because of variability in time and animals.

The crude protein content of 14·1 per cent. in the grains used in these experiments was high. Because of the low level of some essential amino acids, particularly lysine, in all grains (Harvey 1956; Pond, Hillier, and Benton 1958) and the variability in results obtained in experiments which compared low-protein and high-protein grains (McElroy and Draper 1949; Peo and Hudman 1958; Vavich, Kemmerer, and Stith 1959), supplementation in Experiments I and II was maintained at a level consistent with lower protein grains. A ration with a protein content higher than that recommended by the National Research Council (1953) resulted.

The results of Crampton and Whiting (1943) and Watson *et al.* (1946) have shown that from weaning weight onwards there is little effect of age of pig and level of feeding on digestibility of rations. These results were confirmed in the present experiment, the only exception being a greater digestibility of dry matter, organic matter and crude protein in the 40–80-lb body-weight range for the sorghum plus meatmeal ration.

The two major differences between sorghum and wheat were in the markedly higher digestibility of fibre and lower digestibility of crude protein in sorghum. The digestibility of fibre would tend to be of little importance nutritionally, because of the small percentage of this component in grains. The difference in digestibility of protein, however, is of much greater significance. Sorghum grown in Queensland varies in crude protein at least from 5 to 17 per cent. (from analyses made by the Queensland Department of Agriculture and Stock—unpublished data). Meatmeal, which can vary greatly in composition and in protein quality, is commonly used as the sole protein supplement to grain in rations for pigs. In a ration the adverse effects of a meatmeal of poor protein quality, sorghum grain of low protein content and sorghum grain of low protein digestibility are additive. Such a ration compounded on the basis of standard recommendations could provide much less than the minimum recommended digestible protein requirements, particularly for young pigs.

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