Nutrient digestibility and performance of pigs fed sorghum varying in polyphenol concentration and maize as grain sources

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Two experiments were conducted, (1) to determine the effect of the polyphenol content of sorghum on nitrogen and energy digestibility and (2) to compare a high polyphenol content class KF sorghum cultivar (BPS) and a low polyphenol content class KM cultivar (NS) with maize (MM) as grain components in pig growth diets formulated to be equal in DE and lysine content. BPS had a negative effect on dietary nitrogen digestibility when compared to NS. Nitrogen retention when expressed as a percentage of digested nitrogen was however slightly higher for a BPS than for a NS-containing diet (54 % *vs* 49 %). Although paraformaldehyde treatment had an advantageous effect on nitrogen digestibility, nitrogen retention was adversely influenced. Although the DE content of the BPS cultivars was generally lower than that of NS, DE content of the BPS was substantially increased by reducing its polyphenol content with paraformaldehyde treatment. Pigs fed NS had live mass gains between 2 and 13 % higher than BPS-fed pigs, and 4 to 6 % higher than pigs fed maize based diets. Pigs fed the maize containing diets were however the most efficient utilizers of dietary DE, 2 to 4 % better than NS-fed pigs and 7 to 12 % better than BPS-fed pigs.
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Twee studies is uitgevoer, (1) om die effek wat polifenolinhoud op die stikstof- en energieverteerbaarheid van sorghum uitoefen te bepaal en (2) om 'n hoëpolifenolinhoud van klas KF sorghumkultivar (BPS) asook 'n laepolifenol klas KM kultivar (GS) met mielies (MM) te vergelyk as graankomponente in varkgroeidiete saamgestel om ekwivalente VE- en lisieninhoude te bevat. BPS het 'n negatiewe effek op stikstofverteerbaarheid in die dieet uitgeoefen in vergelyking met 'n GS dieet. Stikstofretensie, uitgedruk as 'n persentasie van verteerde stikstof, was egter ietwat hoër vir die BPS dieet (54 % teenoor 49 %). Hoewel paraformaldehied behandeling 'n voordelige invloed op stikstof-verteerbaarheid uitgeoefen het, is stikstofretensie nadelig beïnvloed. Die VE-inhoude van die BPS kultivars was in die algemeen laer as die van die GS kultivars. Die VE-inhoud van die BPS kultivar SSK 32 is egter aansienlik verhoog deur die polifenolinhoud van die kultivar met paraformaldehied behandeling te verlaag. GS-gevoerde varke se massatoenames was tussen 2 en 13 % hoër as dié van BPS-gevoerde varke en 4 tot 6 % hoër as die van die varke wat mieliemeel gebaseerde diëte gevoer is. Die varke wat die mieliegebaseerde diëte gevoer is, was egter die doeltreffendste VE benutters, 2 to 4 % beter as die KM sorghum gevoerde varke en 7 tot 12 % beter as die KF gevoerde varke.
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The results achieved, when different varieties (cultivars) of grain sorghum were compared to one another and to maize have been very contradictory (Tanksley, 1973; Tanksley, 1975; Almond, Smith, Savage & Lawrence, 1979; Cousins, Tanksley, Knabe & Zebrowska, 1981 and Noland, Campbell & Johnson, 1981). Variation in the nutritional value and in particular the polyphenol content of the different grain sorghum cultivars must be held responsible for these differences (Hardy, 1969; Noland, 1976; Noland, Johnson, Sharp & Campbell, 1976; Lawrence, 1967; Counsins *et al.*, 1981 and Noland *et al.*, 1981). Various research workers have in fact already found that variations in the nutritional value and the polyphenol content influence the performance of the growing pig (Tanksley, 1975; Ford, 1977; Sharp, Noland & Campbell, 1977; Almond *et al.*, 1979; Cousins *et al.*, 1981 and Noland *et al.*, 1981). Kemm, Daiber & Ras (1981) and Kemm (1980) have shown that the DE content of the grain is obviously influenced by its polyphenol content. The DE content of a sample with a polyphenol content of 1,1 % increased from 15 to 15,52 MJ/kg DM after the polyphenol content was decreased to 0,32 % through formaldehyde treatment. Another sample with a polyphenol content of 1,64 % had a DE content of only 14,15 MJ/kg DM (Kemm, 1980).

In South Africa sorghum cultivars are divided into two classes, namely bird-proof varieties of the KF class with a dark-brown pericarp and a high polyphenol content (1,13 ± 0,38 %, with a variation of between 0,29 and 1,94 % according to report BB 82 of the CSIR) and the normal yellow pericarp KM class types with a low polyphenol content (0,11 ± 0,12 %, with a variation of between 0,07 and 0,12 %). Since both classes of sorghum are presently produced in similar quantities and sold at a price lower than that of maize, it was deemed necessary to determine the nutritional value of Class KM (normal) and Class KF (bird-proof) sorghum cultivars and to compare the two classes with one another and with maize as grain components in pig growth diets. Two experiments were therefore conducted:

(1) to determine the effect of the polyphenol content of sorghum on nitrogen and energy digestibility and
(2) to compare a high polyphenol content Class KF sorghum cultivar and a Class KM cultivar with maize as grain components in pig growth diets theoretically formulated to be equal in DE and lysine content.

Experimental procedure

Experiment 1

Four sorghum samples selected on their polyphenol (tannin) content were used as experimental material. The samples were made up of a normal sorghum, Class KM, cultivar NK 283 with a total polyphenol content of 0,10 %; a bird-proof, Class KF, cultivar SSK 32 with a 1,42 % polyphenol content and two bird-proof cultivars SSK 52 and DC 99 with intermediary polyphenol content of 0,77 and 0,91 % respectively (Polyphenol content was determined by the modified Jerumanis procedure as described by Daiber, 1975).

Part of the SSK 32 sample was treated with paraformaldehyde with the aim of reducing the polyphenol content to approximately that of the SSK 52, DC 99 and NK 283 samples. Three subsamples of SSK 32 grain were consequently treated with 40 g, 45 g and 176 g of paraformaldehyde, bagged into high-density polyethelyne bags and stored at 16 °C for 40 days (CSIR, 1976). The samples were then milled and rebagged until the start of the digestion trial 52 days later. Polyphenol analyses conducted at this stage revealed the three samples to have polyphenol contents of 1,07 % (SSK 32/1); 0,87 % (SSK 32/2) and 0,38 % (SSK 32/3).

Digestion trials

During the digestion trial the various sorghum cultivars in the diets were substituted at a rate of 25 % in a control diet. This was done to calculate the DE content of the different sorghum cultivars (Siebrits & Ras, 1981).

Group 1: Twelve boars of Landrace × Large White origin, having a mean live mass of 54,3 kg, were used as experimental animals. Four pigs per diet were fed the control diet (Table 1); 75 % control plus 25 % NK 283 sorghum, or 75 % control plus 25 % SSK 32 sorghum.

Group 2: Twenty-four boars of Landrace × Large White origin, having a mean live mass of 72,2 kg, were used. Four pigs per diet were fed the control diet (Table 1); 75 % control plus 25 % SSK 52 sorghum; 75 % control plus 25 % DC 99 sorghum; 75 % control plus 25 % SSK 32/1 sorghum; 75 % control plus 25 % SSK 32/2 sorghum, or 75 % control plus 25 % SSK 32/3 sorghum.

Table 1 Composition of the control diet (Experiment 1)

Ingredient	% in diet
Maize meal	77
Fish meal	11
Wheaten bran	10
Salt	1
Bone meal	1
Vitamins + minerals	+
Diet fed to Group 1 pigs	
Crude protein, in DM	20,88
Gross energy, MJ/kg DM	19,12
Diet fed to Group 2 pigs	
Crude protein, in DM	19,60
Gross energy, MJ/kg DM	19,09

The pigs were subjected to a 14-day trial period consisting of a seven-day preliminary period and a seven-day collection period, during which faeces and urine were collected in metabolism crates. The pigs had free access to water at all times. Pigs in Group 1 were fed 1500 g of air-dry meal per day, and pigs in Group 2 were fed 2000 g per day. The procedures followed in collecting and analysing faeces and urine samples are described in detail by Kemm & Ras (1971).

Chemical analyses

The diets fed were chemically analysed for DM and nitrogen by standard AOAC methods. Polyphenol content of the sorghum samples (Table 4) was determined by the modified Jerumanis procedure as described by Daiber (1975).

Experiment 2

Experimental animals

Seventy-two Landrace type pigs (36 gilts and 36 boars) were randomly allotted to six experimental treatments when 56 days old and 14,4 ± 1,3 kg live mass. Six diets, composed to contain equivalent DE and lysine contents, were fed to 12 animals per diet (six of each sex). The experiment ended when the pigs were slaughtered at 84,5 ± 1,9 kg.

The pigs were individually housed in flat deck-type cages, 1,6 × 1 m, fitted with a self-feeder and an automatic water nipple. Temperatures in the building were controlled to the extent that minimum temperatures never dropped below 20 °C, while maximum temperatures seldom rose above 30 °C. Pigs were fed *ad libitum* at all stages. Feed intake and live mass were recorded every four days. Feed and water were not withdrawn before mass determinations were done.

Treatments

Bird-proof sorghum (BPS), normal sorghum (NS) and maize meal (MM) were used in combination with fish meal (FM) or sunflower oil cake meal (SOC) to formulate the six experimental diets. Bird-proof sorghum of the cultivar SSK 32 with a polyphenol content of 1,42 % and NS of the cultivar NK 283 with a polyphenol content of 0,10 % were used.

Samples of the sorghum, maize, wheaten bran, fish meal and sunflower oil cake meal were analysed for protein and lysine (Table 5), whereafter the figures obtained were used to formulate, by least-cost procedures, the six experimental diets given in Table 6.

Statistical analyses

The model for the description of growth as proposed by Roux (1976) was used to calculate mean live mass gains for the growth interval 20 to 85 kg live mass for each of the two sexes within an experimental treatment. According to the model, live mass is allometrically related to cumulative energy intake. In the time domain cumulative energy intake is described by the equation:

$x_t = \alpha + \rho^t (\mu - \alpha)$ with
x_t = ln (cumulative energy intake) at time t
μ = ln (cumulative energy intake) at time t_o
ρ = the slope of the autoregression of ln (cumulative energy intake)
α = intercept of the autoregression of ln (cumulative energy intake)/1 $- \rho$

Autoregressions of ln (cumulative DE intake) were calculated by correlating the ln of cumulative DE intake at time (t − 1) as x with ln (cumulative DE intake) at time t as y. The relationship between ln (cumulative DE intake) and ln (mass) was then used to calculate feed and DE utilization for each group for the live mass interval 20 to 85 kg (Roux, 1974).

Following two-way analyses of variance on the statistical parameters (Table 7), the parameters (Table 8) were used to calculate the data in Tables 9 and 10 and Figures 1 to 4.

Results and Discussion

Experiment 1

The nitrogen and energy metabolism data for the diets fed to Group 1 pigs are summarized in Table 2. The replacement of 25 % of the control diet with either NS (cultivar NK 283) or BPS (cultivar SSK 32) had small and non-significant effects on DM and energy digestibilities. Both DM and energy digestibilities were slightly raised when NS was used (0,4 and 0,1 % respectively) while BPS reduced these digestibilities by 0,4 and 1,2 %, respectively. Dietary DE content was raised by replacement with NS (from 15,79 to 15,95 MJ/kg DM) while replacement with BPS reduced the DE content from 15,79 to 15,49 MJ. Recently Cousins *et al.* (1981) and Noland *et al,* (1981) also reported reduced energy digestibilities for high-tannin sorghum varieties, while Gous, Kuyper & Dennison (1982) reported a highly significant negative correlation between the ME content of the grain and its tannic acid content in a study with roosters.

Table 2 Nitrogen and energy metabolism data for the diets fed to Group 1 pigs

	Diet		
	Control	C + NK 283	C + SSK 32
DM intake, g/day	1354	1344	1347
GE intake, MJ/day	25,9	25,9	25,6
N intake, g/day	45,2	38,7	38,2
DM digestibility, %	83,3 ± 1,3	83,7 ± 1,2	82,9 ± 1,4
N digestibility, %	83,7 ^{a}± 2,1	79,0 ^{b}± 2,0	75,3 ^{c}± 1,5
Energy digestibility, %	82,6 ± 1,2	82,7 ± 1,1	81,4 ± 1,4
N retention, g/day	20,5 ^{a}± 0,6	15,0 ^{b}± 1,6	15,6 ^{b}± 0,6
N retention, % of intake	45,4 ^{a}± 1,4	38,9 ^{b}± 4,0	40,8^{bc}± 1,6
N retention, % of digested N	54,4	49,0	54,2
DE, MJ/kg DM	15,79 ± 0,2	15,95 ± 0,2	15,49 ± 0,3

Means with different superscripts differ significantly.
Least significant differences:
N digestibility, $P \leq 0,01$ = 4,36 %; $P \leq 0,05$ = 3,03 %. N retention, g/day $P \leq 0,01$ = 2,41 g/day; $P \leq 0,05$ = 1,68 g/day. N retention, % of intake $P \leq 0,01$ = 5,99 %; $P \leq 0,05$ = 4,17 %.

Nitrogen digestibilities were significantly lower ($P \leq 0,01$) than in the control diet when using the NS diet (4,3 %), or the BPS diet (8,3 %) with a significant ($P \leq 0,05$) difference of 3,7 % in favour of NS between the two sorghum-containing diets. While indicating that despite the fact that the lower nitrogen digestibilities of the sorghum diets can partly be ascribed to lower nitrogen intakes and a reduced dietary protein quality, BPS had an appreciably larger negative effect on nitrogen digestibility when compared to NS.

Although the above reasons must have contributed towards the lower ($P \leq 0,01$) nitrogen retention of the sorghum containing diets, it is interesting to note that nitrogen retention when expressed as a percentage of digested nitrogen was similar for the control and BPS diets (54 %) and lower for the NS diet (49 %). Digested nitrogen was therefore better utilized when BPS was used instead of NS. These findings are in full agreement with that of Cousins *et al.* (1981).

The nitrogen and energy metabolism data for the diets fed to Group 2 pigs are presented in Table 3. Partial replacement of the control diet with different BPS cultivars (SSK 52, DC 99 and paraformaldehyde treated SSK 32) resulted in small non-significant differences in the DM and energy digestibilities of the diets. Although non-significant, a distinct improvement in the digestibility of both DM and energy occurred after paraformaldehyde treatment of the SSK 32 sorghum. Each additional amount of paraformaldehyde added to the grain resulted in an improvement in digestibility indicating that the amount of polyphenol present in the sorghum has an effect on the digestibility of DM and energy. Kemm *et al.* (1981) were also able to improve the energy digestibility of BPS by treating it with formalin.

Nitrogen digestibilities for the diets supplemented with SSK 52, DC 99, SSK 32/1 and SSK 32/2 sorghum were all lower ($P \leq 0,01$) than the control and C + SSK 32/3 diets (between 7,3 and 4,7 percentage units). Paraformaldehyde treatment of the SSK 32 sorghum improved nitrogen digestibility from 79,8 % (SSK 32/1) to 84,8 % (SSK 32/3), to such an extent that the maximum treatment imposed resulted in the SSK 32/3-containing diet having a nitrogen digestibility only 2,3 percentage units lower (statistically non-significant) than the control diet. Treatment differences in nitrogen retention were small and non-significant with a tendency towards lower retentions in the diets supplemented with SSK 32/2 and SSK 32/3 grain. Hence, nitrogen retention when expressed as a percentage of digested nitrogen, decreased with increased paraformaldehyde treatment (64,9; 57,3 and 55,3 % for diets with SSK 32/1; SSK 32/2 and SSK 32/3 grain respectively). This indicates that although paraformaldehyde has a beneficial effect on nitrogen digestibility, nitrogen retention is adversely affected, thus substantiating the results of Kemm *et al.* (1981).

Table 3 Nitrogen and energy metabolism data for the diets fed to Group 2 pigs

	Diet fed					
	Control	C + SSK 52	C + DC 99	C + SSK 32/1	C + SSK 32/2	C + SSK 32/3
DM intake, g/day	1794	1780	1782	1785	1773	1774
GE intake, MJ/day	34,2	34,3	34,2	34,6	34,0	34,3
N intake, g/day	56,3	46,9	48,0	47,9	48,4	48,2
DM digestibility, %	86,2 ± 1,3	86,9 ± 2,3	85,0 ± 2,2	85,0 ± 2,1	85,4 ± 0,3	86,7 ± 1,9
N digestibility, %	87,1^{a} ± 1,7	82,4^{bc} ± 2,2	80,0^{b} ± 2,9	79,8^{b} ± 2,7	81,2^{b} ± 0,9	84,8^{ac} ± 2,4
Energy digestibility, %	85,0 ± 1,3	85,6 ± 2,4	83,9 ± 1,7	83,8 ± 1,7	84,0 ± 0,2	85,6 ± 2,2
N retention, g/day	24,2 ± 4,2	23,4 ± 3,1	24,5 ± 2,6	24,8 ± 4,5	22,5 ± 3,4	22,6 ± 3,6
N retention, % of intake	43,0 ± 7,5	50,0 ± 6,6	51,0 ± 5,4	51,7 ± 9,4	46,5 ± 7,0	46,8 ± 7,5
N retention, % of digested	49,4	60,6	63,8	64,9	57,3	55,3
DE, MJ/kg DM	16,23 ± 0,2	16,49 ± 0,5	16,03 ± 0,3	16,27 ± 0,3	16,12 ± 0,04	16,52 ± 0,4

Means with different superscripts differ significantly.
Least significant differences between N digestion $P \leq 0,01$ = 4,50 %; $P \leq 0,05$ = 3,29 %.

The DE content of the various sorghum cultivars used (calculated as described by Siebrits & Ras, 1981) are summarized in Table 4. The calculated DE content of the NS (NK 283) cultivar with a polyphenol content of 0,10 %, was 12,6 % higher than that of the BPS (SSK 32) cultivar which had a 1,42 % polyphenol content. The DE value calculated for BPS cultivar SSK 52 (17,27 MJ/kg DM) was 11,9 % higher than that of DC 99 and, although not strictly comparable, 5,1 % higher than that of NK 283 grain. Paraformaldehyde treatment of the SSK 32 grain not only reduced the polyphenol content to 1,07; 0,87 and 0,38 % but increased dietary DE content by 11; 7,6 and 19,2 % above the 14,59 MJ/kg DM calculated for the untreated SSK 32 grain. The above results are therefore in agreement with the reports of Cousins *et al.* (1981) and Noland *et al.* (1981) on pigs and Gous *et al.* (1982) on roosters.

Experiment 2

A two-way analysis of variance of the calculated statistical parameters revealed that the ρ and α values do not differ significantly between treatments or sex (Table 7). Highly significant differences were however found between the slope (b) and intercept (a) values of the regression relationships between ln (cumulative DE intake) and ln (live mass). Consequently the parameters in Table 8 were used to calculate separate values for feed and DE intakes, gains in live mass and utilization efficiencies of feed and DE for each of the two sexes within a treatment. The data given in Table 9 and 10 and Figures 1 to 4 represent values calculated for each Treatment.

Table 4 Polyphenol concentrations and calculated DE values of the different sorghum cultivars studied

Sorghum cultivar	Polyphenol concentration %		Calculated DE values, MJ/kg DM
	Sorghum	Mixed diet	
Group 1			
Control diet	–	0,03*	15,79
NK 283	0,10	0,05**	16,43
SSK 32	1,42	0,50**	14,59
Group 2			
Control diet	–	0,04**	16,23
SSK 52	0,77	0,19**	17,27
DC 99	0,91	0,23**	15,43
SSK 32/1	1,07	0,29*	16,39
SSK 32/2	0,87	0,29*	15,79
SSK 32/3	0,38	0,12*	17,39

* Analysed at the start of the digestion trials.
**Analysed 12 months later.

Initially, the BPS fed groups (treatments 1 and 4) had higher feed intakes, 1,50 and 1,51 kg air-dry feed/day at 20 kg live mass, while pigs fed the maize based diets (treatments 3 and 6) had the lowest intakes, 1,35 and 1,30 kg/day, differences that are respectively 10 and 13 % lower than that of treatment 1 pigs. Maximum feed intakes achieved at mean live masses of 73 and 66 kg for the BPS-fed groups (treatments

Table 6 Experimental diets computed by least cost procedures using the figures presented in Table 5

Diet	Treatment No.					
	1	2	3	4	5	6
Bird-proof sorghum (BPS), %	87,63	–	–	58,10	–	–
Normal sorghum (NS), %	–	75,30	–	–	77,19	–
Yellow maize meal (MM), %	–	–	62,82	22,40	–	59,64
Wheaten bran, %	–	13,70	28,37	–	5,33	19,36
Fish meal (FM), %	9,82	7,60	5,81	–	–	–
Sunflower oil cake meal (SOC), %	–	–	–	15,50	12,96	17,41
Feed lime, %	1,00	1,80	1,44	1,66	2,29	1,85
Mono calcium phosphate, %	0,06	–	–	0,63	0,47	0,15
Salt, %	1,00	1,00	1,00	1,00	1,00	1,00
Synthetic lysine**, %	0,285	0,370	0,355	0,500	0,560	0,380
Vitamins + minerals, %	0,20	0,20	0,20	0,20	0,20	0,20
Calculated composition						
Protein, %	15,10	15,35	15,95	15,31	15,00	18,00
Lysine, %	0,80	0,80	0,80	0,80	0,80	0,80
DE, MJ/kg feed (calculated)	13,00	13,00	13,00	13,00	13,00	13,00
DE*, MJ/kg feed (determined)	13,28	13,33	12,84	12,69	12,56	12,66

* Determined in a digestion trial with four pigs per diet.
** Lysine monohydrochloride was used.

Table 7 F-values of two-way analyses of variance on the statistical parameters in Table 6

	DF	$\bar{\rho}$	$\bar{\alpha}$	$\bar{b}$	$\bar{a}$
Treatments	5	0,4	0,5	4,9**	8,2**
Sexes	1	3,6	0,1	20,0**	15,4**
Interaction	5	0,7	0,8	0,3	0,3
Error	60	–	–	–	–

** Significant at $P \leq 0,01$.

Table 5 Composition of the feedstuffs used in formulating the experimental diets in Table 6

Ingredient	Protein*	Lysine*	Cystine** + Methionine %	Tripto-** phane %	DE MJ/kg	Fibre** %	Ca**%	P**%	Fat**%	Price R – c
Bird-proof sorghum (BPS)	9,37	0,188	0,27	0,09	13,33[a]	2,0	0,04	0,29	2,8	110-00
Normal sorghum (NS)	10,32	0,175	0,27	0,09	14,04[a]	2,0	0,04	0,29	2,8	110-00
Maize meal (MM)	11,60	0,247	0,30	0,09	14,84**	2,5	0,02	0,20	3,5	145-60
Wheaten bran	15,76	0,426	0,41	0,30	10,19**	11,0	0,13	0,90	4,0	121-40
Fish meal (FM)	67,24	4,170	2,50	0,75	13,57**	1,0	4,00	2,40	10,0	420-00
Sunflower oil cake (SOC)	44,38	1,534	2,20	0,50	12,40**	20,0	0,04	1,00	6,3	204-00

* Figures obtained from analysis of the feedstuffs used in this experiment.
** Theoretical figures.
[a] Determined in a digestion trial by Kemm (1981, unpublished).

1 and 4) and 79 kg for the NS-fed pigs were consequently 2 and 10 % higher in the NS-fed pigs than in the BPS-fed groups.

Table 9 and Figures 1 and 2 further indicate that intakes of both feed and DE not only tended to decrease at a faster rate in BPS-fed pigs (after maximum intake), but also, when BPS was fed in combination with SOC (treatment 4), feed and energy intake declined sharply towards the end of the experiment. At a live mass of 85 kg NS-fed pigs consumed 4 and 8 % (treatments 2 and 5) more feed than treatment 1 pigs, while treatment 4 pigs consumed 8 % less than treatment 1 pigs.

The differences in feed and DE intake, described above, together with appreciable differences in feed and DE utilization (Table 10) resulted in treatment 4 pigs showing an alarming decline in daily live mass gain above a live mass of 30 kg (Figures 3 & 4). Over the entire experimental period pigs fed the NS diets had mean daily gains (Table 10) that were 2 and 4 % higher than treatment 1 pigs and 4 to 8 % higher than treatment 3 and 6 pigs. The daily gains of treatment 4 pigs fed BPS in combination with SOC were 9 % lower than that

Table 8 Statistical parameters used in calculating the data presented in Tables 7 and 8 and Figures 1, 2 and 3

Treatment No	Statistical parameters				
	$\bar{\rho}$ ln (per 4 days)	$\bar{\alpha}$ ln (MJ)	$\bar{\mu}$ ln (MJ)	$\bar{b}$ (DE × mass)	$\bar{a}$ (DE × mass)
Boars					
1	0,9458	8,9562	6,6301	0,8218	−2,1703
2	0,9451	8,9657	6,5713	0,7948	−1,9041
3	0,9414	8,7391	6,5718	0,7933	−1,8955
4	0,9415	8,7966	6,5480	0,7975	−2,0270
5	0,9473	8,9292	6,6147	0,8181	−2,0865
6	0,9450	8,8323	6,5265	0,7843	−1,7944
Gilts					
1	0,9455	8,8417	6,5814	0,8032	−2,0921
2	0,9460	8,8749	6,4902	0,7634	−1,7221
3	0,9520	9,0179	6,4198	0,7721	−1,7267
4	0,9463	8,7739	6,4904	0,7693	−1,7983
5	0,9486	8,9567	6,5246	0,7855	−1,9060
6	0,9506	8,8746	6,4746	0,7419	−1,5181

Table 9 Computed feed intakes at specific pre-selected live masses

	Treatment no.					
	1	2	3	4	5	6
Grain source used	BPS	NS	WM	BPS + MM	NS	MM
Protein source used	FM	FM	FM	SOC	SOC	SOC
Intakes at 20 kg live mass						
Boars (kg/day)	1,50	1,41	1,44	1,61	1,46	1,37
Gilts (kg/day)	1,49	1,36	1,26	1,41	1,46	1,23
Treatment means (kg/day)	1,50 (100)	1,38 (92)	1,35 (90)	1,51 (101)	1,46 (97)	1,30 (87)
Maximum intakes						
Live mass of pigs (kg): Boars	79	84	70	66	81	77
Gilts	67	73	85	66	77	75
Boars (kg/day)	2,99	3,05	2,70	2,89	2,99	2,82
Gilts (kg/day)	2,68	2,74	2,91	2,59	3,00	2,63
Treatment means (kg/day)	2,84 (100)	2,90 (102)	2,81 (99)	2,74 (96)	3,00 (106)	2,73 (96)
Intakes at 85 kg live mass						
Boars (kg/day)	2,98	3,05	2,60	2,71	2,99	2,79
Gilts (kg/day)	2,54	2,68	2,91	2,40	2,97	2,59
Treatment means (kg/day)	2,76 (100)	2,86 (104)	2,75 (100)	2,55 (92)	2,98 (108)	2,69 (97)

Table 10 Growth, feed and DE utilization data calculated for the growth interval 20 to 85 kg live mass

	Treatment no.					
	1	2	3	4	5	6
Grain source used	BPS	NS	MM	BPS + MM	NS	MM
Protein source used	FM	FM	FM	SOC	SOC	SOC
Lives mass gain (g/day)						
Boars	841	874	795	756	836	813
Gilts	718	742	770	666	756	686
Treatment means	780 (100)	808 (104)	783 (100)	711 (91)	796 (102)	750 (96)
Feed utilization (kg/kg gain)						
Boars	3,00	2,86	2,96	3,39	2,97	2,91
Gilts	3,30	3,15	2,99	3,43	3,34	3,22
Treatment means	3,15 (100)	3,00 (95)	2,98 (95)	3,41 (108)	3,16 (100)	3,07 (97)
DE utilization (MJ/kg gain)						
Boars	39,8	38,1	38,0	43,0	37,3	36,8
Gilts	43,8	42,0	38,4	43,5	42,0	40,8
Treatment means	41,8 (100)	40,1 (96)	38,3 (92)	43,3 (104)	39,7 (95)	38,9 (93)

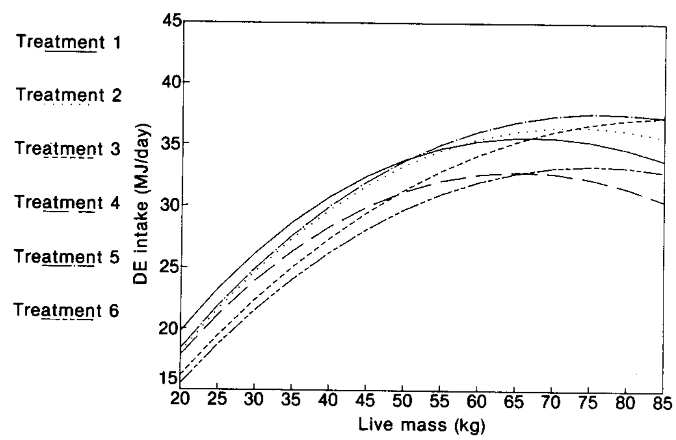

Figure 1 Daily gilt DE intakes at different live masses.

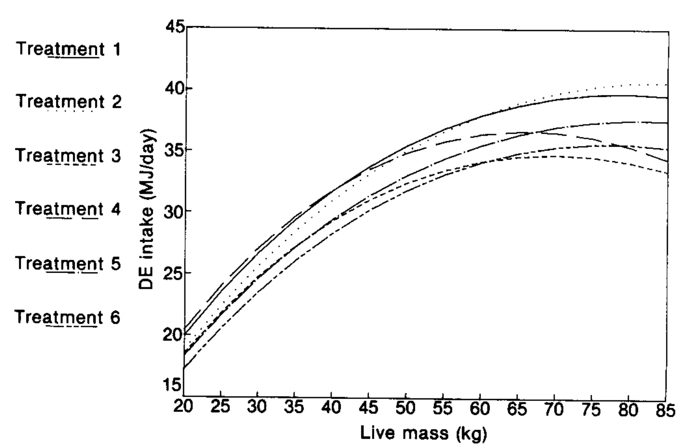

Figure 2 Daily boar DE intakes at different live masses.

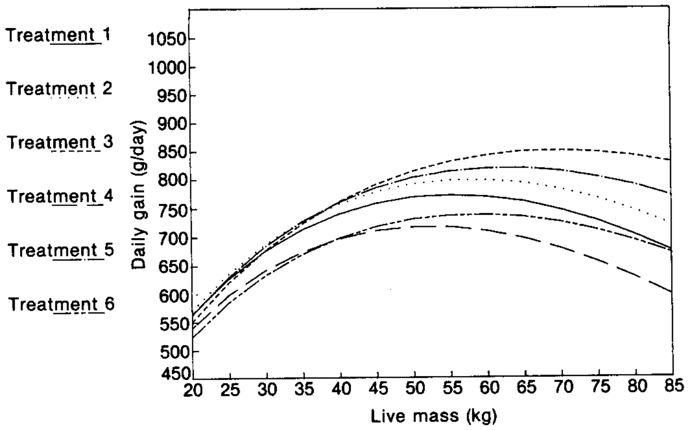

Figure 3 Daily gilt live mass gains.

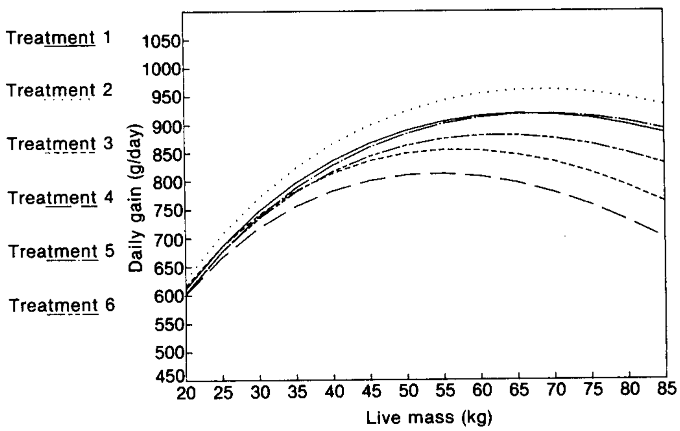

Figure 4 Daily boar live mass gains.

of treatment 1 pigs and between 5 and 13 % lower than that of the other treatments. This suggests that BPS should not be fed in combination with SOC.

Pigs fed the maize based diets were the most efficient converters of dietary DE into live mass, with treatments 3 and 6 being respectively 8 and 7 % more efficient than treatment 1 pigs and between 2 and 12 % more efficient than in the other treatments.

Conclusions

The results of this experiment and the fact that pigs fed formalin-treated BPS do not perform better than pigs fed untreated grain (Kemm *et al.*, 1981), reaffirm the suggestion put forward by Kemm *et al.* (1981) that basic studies be done to investigate the biological utilization of the protein and energy fractions of treated and untreated grain sorghum. It was furthermore shown that pigs fed the NS cultivar NK 283 perform just as well if not slightly better than when maize is used as the grain source. The use of BPS (SSK 32) on the other hand, not only results in reduced gains in live mass and feed utilization, but indications were also found that the combination of BPS and SOC result in a drastically reduced feed intake above 30 kg live mass with a resultant drop in performance. This emphasises the need to investigate the cause of this finding.

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