The use of whole-grain mixtures in diets of growing-finishing pigs

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Small-scale farmers in the rural areas of South Africa do not have milling and mixing facilities at their disposal. A study was conducted to quantify the production as well as the energy and nitrogen metabolism of pigs when fed a balanced whole-grain mixture or milled diet composed of a wheat/barley mixture as grain source. The whole-grain mixture was prepared with the use of minimal mechanical equipment and ingredients were bound to the grain by molasses. Growing pigs (28–89 kg) consumed 7.8% less feed per day, grew 11.2% slower and had a 10% poorer feed conversion ratio when fed a barley plus wheat-containing whole-grain diet compared to the milled diet. Energy and nitrogen metabolism data similarly revealed 5.9% higher DM digestibility and a 6.6% higher digestible energy value for the milled diet. Possible production losses therefore had to be counterbalanced against the price of commercially produced meal or the cost of the ability to process the grain.

Klein, nie-kommersiële boere in Suid-Afrika het geen meng- en maal-toerusting tot hul beskikking nie. 'n Studie is uitgevoer om die produksie sowel as die energie- en proteïenmetabolisme van varke op 'n gebalanseerde heelgraanmengsel teenoor 'n gemaalde dieet, wat uit 'n koring/garsmengsel as graanbron bestaan, te evalueer. Die heelgraandieet is sonder meganiese verwerking voorberei en bykomstige bestanddele is met melasse aan die graan gebind. Gedurende die groeistudie het groeiende varke (28–89 kg) 7.8% minder van 'n koring/gars heelgraanmengsel as van 'n meeldieet ingeneem, 11.2% stadiger gegroei en het 'n 10% swakker voeromset gehad. Energie- en stikstofmetabolismedata het soortgelyk op 'n 5.9% hoër DM-verteerbaarheid en 6.6% hoër verteerbare energie by die gemaalde graan gedui. Moontlike produksieverliese moet dus opgeweeg word teen die pryse van kommersieel geproduseerde meel of die koste van fasiliteite om die graan te verwerk.

Keywords: cereal grain, metabolism data, production data, pigs, whole-grain mixtures

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It is well known that grinding as well as various other mechanical processing methods improve the nutritional value of cereal grains for pigs. Normally the digestibility of the grain increases with a resultant improvement in intake, feed conversion ratio and growth rate of the pig (Hutton & Armstrong, 1976; Lawrence, 1978). Lawrence (1970) indicated apparent DM digestibility values of 80.5 and 63.6%, daily growth rates of 660 and 510 g/day and feed conversion ratios of 3.14 and 3.98 kg food/kg gain for pigs fed ground (1.56 mm) or whole barley. Ivan *et al.* (1974) reported apparent DM digestibility values of 86.2 and 75.5% and apparent N digestibility values of 90.0 and 75.3% when pigs were fed finely ground or whole wheat. Small-scale farmers in South Africa, however, do not have milling and mixing facilities at their disposal or the money needed to set up these facilities. Excellent results were obtained locally by feeding balanced whole-grain mixtures to lambs (Brand & Van der Merwe, 1994), based on systems proposed by Ørskov *et al.* (1974). This study was conducted to measure the response of pigs when fed a balanced whole-grain mixture composed of wheat and barley and prepared with the use of minimal mechanical equipment, compared to a milled diet with the same ingredient composition.

An experimental diet was formulated with locally available small grains as an energy source to contain 13.6 MJ/kg digestible energy (DE), 18% crude protein (CP), 1.2% lysine, 0.75% methionine and cystine and 0.19% tryptophan on an as-fed basis (Table 1). In the first treatment the grain used was hammermilled through a 6-mm sieve and thoroughly mixed with the other ingredients in a vertical mixer. In the second treatment the grain used was wetted with water (50 ℓ/ton). The other ingredients were mixed, added to the wetted whole grain and again thoroughly mixed with spades. Molasses powder acted as a binding substance.

The differently treated diets were evaluated in a growth trial with 30 Large White × Landrace pigs (15 gilts and 15 castrated boars) approximately 90 days of age with a mean live mass of 27.8 ± 0.4 kg. Pigs were individually housed in flat-deck-type cages (1.6 × 1 m), fitted with a self-feeder and equipped with an automatic water nipple. The experimental diets were fed *ad libitum* to 15 pigs per diet (7 castrated boars and 8 gilts on treatment 1 and 8 castrated boars and 7 gilts on treatment 2) for 78 days. The trial ended when the pigs were slaughtered at a live mass of 89.4 ± 1.4 kg. Daily dry-matter intake (DMI) and average daily gain (ADG) for each individual pig were recorded and feed conversion ratio (FCR) calculated.

After the pigs were slaughtered, the carcasses were stored in a refrigerator for 24 h at 4°C and dressing percentages (cold carcass) determined. The thickness of the back fat (P2 back fat measurement) and the percentage of meat in the carcass [percentage meat = 72.5114 – (0.4618 × fat thickness in mm) + (0.0547 × muscle thickness)] were subsequently determined with the Hennesy probe (Government Gazette, 1992).

The two differently processed diets were also compared to each other in a metabolism trial. Twelve Large White × SA Landrace castrated boars with a mean live mass (± SD) of 28.9 ± 3.3 kg were used as experimental animals. Pigs were subjected to a 10-day adaption period and a 5-day collection period, during which faeces and urine were collected, while pigs were housed in metabolism crates. Pigs had free access to water at all times. Pigs were fed 1 200 g of each diet/day in

Table 1 Ingredient and nutrient composition of the experimental diet which was fed to pigs either as a whole-grain mixture or as a meal diet

Composition (% as-fed basis)	
Wheat	41.5
Barley	41.5
Fish-meal	11.5
Molasses powder	3.0
Fine salt	1.0
Dicalcium phosphate	0.6
L-lysine HCl	0.4
Feedlime	0.3
Minerals and vitamins*	0.2
Determined analysis (DM basis)	
Dry matter, %**	89.4
Ash, %	6.3
Crude protein, %	18.2
Crude fibre, %	5.2
Ether extract, %	2.8
Calcium, %	1.1
Phosphorus, %	0.6

* Supplied per kg diet: Vitamin A, 6 000 IU; Vitamin D3, 1 200 IU; Thiamine, 1 mg; Riboflavin, 3 mg; Pyridoxine, 2 mg; Folic acid, 1 mg; Cyanocabalamin, 0.015 mg; Vitamin E, 30 mg; Choline chloride, 100 mg; Niacin, 15 mg; Pantothenic acid, 10 mg; Vitamin K, 1 mg; Biotin 0.1 mg; Zn, 200 mg; Mn, 140 mg; Fe, 100 mg; Cu, 20 mg; Co, 3 mg; I, 0.6 mg.

** DM content for the meal and whole-grain diet were 92.1 and 86.6% respectively.

two equal portions at 08:00 and 13:00. Representative samples from the respective diets were chemically analysed for ether extract (EE), crude fibre (CF), calcium (Ca) and phosphorus (P), while ingredients and diets as well as urine and faeces samples were chemically analysed for dry matter (DM) and nitrogen (N) by standard AOAC methods (Association of Official Analytical Chemists, 1975). Gross energy determinations on the diets, faeces and urine samples were carried out on a CP 400 adiabatic bomb calorimeter (Gallenkamp, Crawley). Procedures followed in collection, preservation and analysis of faeces and urine samples were described in detail by Kemm & Ras (1971).

Growth data were analysed according to a 2 (sex) × 2 (diet) factorial design. Uneven numbers of gilts and boars resulted in the data set being unbalanced and necessitated the use of a general linear model procedure to adjust treatment means accordingly. Differences between treatment means during the metabolism trial were analysed by one-way analysis of variance (Statgraphics 5.0, 1991).

The chemical composition of the experimental diet is presented in Table 1. The CP content of the barley (10.6%) was slightly lower than the mean value reported by Brand & Swart (1995) for locally produced barley (11.4 ± 1.3% with a range of 8.8–14.0%). The CP of the wheat (14.6%) corresponded to the locally accepted value (14.3 ± 2.2% with a range of 10.9–19.2%; Brand & Burger, 1996).

Performance data of pigs are presented in Table 2. No significant interaction was observed between diet and sex and results are presented for the effect of diet only. Pigs on the whole-grain diet consumed 7.8% ($p \leq 0.05$) less feed per day than pigs on the meal diet, while the growth rate of pigs on whole grain was reduced by 11.2% ($p \leq 0.01$). The feed conversion ratio of pigs fed whole grain was 10% ($p \leq 0.01$) poorer compared to the milled diet.

Table 2 Dry-matter intake (DMI), live mass gain, feed conversion ratio (FCR) and carcass data of pigs (n = 15) fed either a meal or whole-grain diet with the same ingredient composition for the growth interval 28–89 kg (mean ± *SE*)

	Diet		
	Meal diet	Whole-grain diet	*SE*
Growth data			
DMI (g per day)	2376^{a} (100)	2190^{b} (92)	63
Live mass gain (g per day)	836^{a} (100)	742^{b} (89)	22
FCR (kg feed per kg gain)	3.09^{a} (100)	3.40^{b} (110)	0.05
Carcass data			
Dressing percentage (%)	76.6^{ns}	76.0^{ns}	0.3
P2 back fat (mm)	21.6^{a}	19.1^{b}	0.8
Meat in the carcass (%)	65.2^{ns}	66.3^{ns}	0.4

^{a,b} Denote significant ($p \leq 0.05$) differences between treatments. Figures in parentheses are percentages of the meal diet.

Back fat of pigs utilizing whole grain was 12% ($p \leq 0.05$) less than those of pigs that utilized meal (see Table 2). No significant differences were observed in terms of dressing percentage and the percentage meat in the carcasses.

Energy metabolism data (Table 3) revealed a 5.9% ($p \leq 0.05$) advantage in DM digestibility and a 6.6% ($p \leq 0.05$) advantage in DE content in favour of the meal diet. ME content and apparent N digestibility also tended ($p \leq 0.10$) to be lower on the whole grain diet.

Pigs on the whole-grain diet generally maintained lower production levels compared to pigs on the meal diet. Although Frape *et al.* (1968) found no significant differences in the feed conversion of growing pigs fed whole or rolled barley, several other studies and reviews (Haugse *et al.*, 1966; Lawrence, 1970; 1978; Hutton & Armstrong, 1976) indicated an improvement when most cereal grains were mechanically processed. This reduced production, owing to the consumption of whole grain, is mostly clarified by the poorer energy and metabolism data observed in this study as well as in other studies (Frape *et al.*, 1968; Ivan *et al.*, 1974; Lawrence, 1970).

Carcass quality of pigs was not adversely affected by the different diets. Generally the higher energy contents of the meal diet resulted in higher P2 fat values. This phenomenon was also found in other studies (Lawrence, 1968; Brand *et al.*, 1995).

Pigs that received whole-grain mixtures maintained lower production levels than pigs on milled diets, as was expected. Small-scale farmers in the rural areas of South Africa, however, do not have milling and mixing facilities at their disposal. Possible production losses therefore had to be counterbalanced against the price of commercial meal or the cost of the ability to process the grain.

Table 3 Energy and nitrogen metabolism data for the experimental diet which was either fed as a whole-grain mixture or as a meal

	Diet	
	Meal	Whole grain
Energy metabolism data		
DMI (g DM per day)	1105	1039
DM digestibility (%)	$84.5^{a} \pm 0.6$	$79.8^{b} \pm 1.8$
DE (MJ/kg DM)	$14.5^{a} \pm 0.1$	$13.6^{b} \pm 0.3$
ME (MJ/kg DM)	$13.8^{1} \pm 0.2$	$13.0^{2} \pm 0.3$
Nitrogen metabolism data		
N intake (g DM per day)	32.2	30.3
Apparent N digestibility (%)	$82.9^{1} \pm 0.7$	$78.9^{2} \pm 2.0$
Apparent N retention (%)	$15.6^{ns} \pm 0.6$	$14.8^{ns} \pm 1.4$
N retention as % of N intake	$48.8^{ns} \pm 1.9$	$48.9^{ns} \pm 5.6$

^{a,b} Denote significant ($p \leq 0.05$) differences between treatments

^{1,2} Denote tendencies ($p \leq 0.10$)

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