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THE EVALUATION AND STANDARDISATION OF PIG RATIONS UNDER SOUTH AFRICAN CONDITIONS: 1. A CHEMICAL AND BIOLOGICAL EVALUATION OF A STANDARD GROWTH RATION

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OPSOMMING: DIE EVALUERING EN STANDAARDISERING VAN VARKRANTSOENE ONDER SUID-AFRIKAANSE TOESTANDE: 1. 'N CHEMIESE EN BIOLOGIESE EVALUASIE VAN 'N STANDAARD GROEIRANTSOEN

Twee proewe is uitgevoer om 'n standaard varkrantsoen te evalueer. 'n Volledige ontleding van die rantsoen en rantsoenbestanddele is met behulp van chemiese analise en 'n metabolismeproef uitgevoer, terwyl die biologiese benutting van die rantsoen in 'n ander proef waarin die groei, voerbenutting en karkassamestelling van varke nagegaan is. Behalwe vir die lisieninhoud van die vismeel en die algemene aminosuurpatroon van die koringsemels gebruik vergelyk die chemiese samestelling van die rantsoen en rantsoenbestanddele gunstig met dié verkry deur ander navorsers en ook met die aanvaarde standaarde vir 'n soortgelyke rantsoen. Gunstige groei, voeromsetting en karkassamestelling is met spekvarke wat die standaard rantsoen gevoer is verkry. Gevolglik kan die inligting ingewin as basis dien vir die daarstelling van voedingstandaarde vir varke onder Suid-Afrikaanse toestande.

SUMMARY

Two experiments were conducted (1) to evaluate a standard pig ration by complete analysis of the ration and its ingredients with the aid of chemical analyses and a metabolism trial and (2) to investigate the biological utilization of the ration by determining the growth, feed utilization and carcass composition of pigs fed the abovementioned ration, with the object of using the results in laying down preliminary nutrient requirements for pigs. Except for the lysine content of the fish meal and the general amino acid pattern of the wheaten bran used the chemical composition of the ration and ration constituents compared favourably with that of other workers and with the accepted standards for a similar ration. Favourable growth, feed conversion and carcass composition were obtained with baconers fed the standard ration. The information gained in the evaluation of the ration, composed of locally available ingredients, could be used as a basis for laying down nutrient requirements for pigs under South African conditions.

The study group of the South African Society of Animal Production, appointed to lay down nutrient requirements for pigs, has already expressed concern at the lack of local information whereupon recommendations can be made. The nutritive value of South African fodder crops for cattle and sheep has been determined in digestion trials by van Wyk, Oosthuizen & Fourie (1948), van Wyk, Oosthuizen & Basson (1951) and van Wyk, Oosthuizen, Meyer, Brewis & Grobler (1955). Similar information applicable to pigs does however not exist.

The experiments reported here were consequently initiated (1) to evaluate a standard pig ration made up of ingredients normally used in South Africa by complete analysis of the ration and its ingredients with the aid of chemical analyses and a metabolism trial and (2) to investigate the biological utilization of the ration by determining the growth, feed utilization and carcass composition of pigs fed the above mentioned ration with the object of using the results in laying down preliminary nutrient requirements for pigs.

Procedure

Thirty-two Landrace and Landrace X Large White crossbred pigs weighing on an average 23.6 kg and between 68 and 76 days old were used in two trials conducted to evaluate a standard pig ration compiled as indicated in Table 1.

Table 1

Composition of standard ration

	%
Yellow maize meal	70,5
Lucerne meal	5,2
Wheaten bran	10,4
Fish meal	12,5
Salt	0,15
Dicalcium phosphate	0,68
Minerals and Vitamins*	0,15
Limestone powder	0,36

* A kg of the Mineral and vitamin mixture contains:– 5 000 000 i.u. Vitamin A; 2 000 000 i.u. Vitamin D3; 2 000 i.u. Vitamin E; 2 000 mg Riboflavin; 15 000 mg Niacin; 5 000 mg Calcium Panthonate; 5 mg Vitamin B12; 40 g Iron; 40 g Manganese; 94 g Zinc; 10 g Copper and 1 g Iodine per kg inert carrier.

Metabolism trial

Twelve castrates divided into two groups of six pigs each were used. The one group was individually fed a restricted amount of feed twice daily according to the amounts given in Table 2, while the other group had free access to feed up to a live-weight of 50 kg whereafter they were restricted to a maximum of 2.27 kg of air dry feed per pig daily. At an average weight of 38.4 kg and again at 72.6 kg the pigs were put into metabolism crates for a period of five days during which faeces and urine collections were made. Whilst in the metabolism crates the pigs had free access to water and were fed as indicated above. Feed not consumed by the animals was weighed back daily. Daily collections of faeces and urine were made. One-tenth of the daily faecal excretion was sampled and dried at 100°C for 24 hours. The accumulated samples for each pig was then ground, sampled and stored in an airtight container for analysis. Hydrochloric acid was used as urine preservative. Urine pH was adjusted to between 2 and 4. Daily urine volumes were measured, a 10% sample taken for analysis and the accumulative samples for each pig stored at 4°C.

Table 2

Abbreviated feed table for pigs fed a restricted amount of feed

Weight of pig	Quantity of air-dry feed
kg	kg
20,0 and less	0,980
22,5	1,095
25,0	1,240
27,5	1,400
30,0	1,580
32,5	1,650
35,0	1,709
37,5	1,827
40,0	1,936
42,5	1,981
45,0	2,027
47,5	2,127
50,0 and heavier	2,273

The nitrogen, moisture, ether extract and ash contents of the feed, feed constituents, faeces and urine and the crude fibre content of the feed, feed constituents and faeces were analysed according to the methods of the A.O.A.C. (1955). The figures obtained were used to calculate the crude-protein (NX6.25), digestible protein, fibre, fat, ash and total digestible nutrient (TDN) contents of the ration.

The amino acid composition of the ration, ration ingredients and the faeces was determined with a Beckman Model 120C amino acid analyser. Samples of between 10 and 20 mg were hydrolysed in closed tubes with 2 ml of a 6 N–HCl solution at 110°C for 24 hours. The tubes were strongly evacuated prior to sealing. After hydrolysis excess HCl was removed with the aid of a vacuum pump, and 5 ml of a citrate buffer pH2.2 added to the residue. The hydrolysates were then filtered through a centriflo cone by centrifugation and then filtered through a Diaflo-ultrafilter which retains everything with a molecular mass in excess of 500. Separation of the amino acids on the columns of the amino acid analyser took 3 hours. Details of the procedures followed were given in the Beckman manual.

The energy content of the feed, faeces and urine was determined with an automatic adiabatic bom calorimeter. The energy content of the feed and faeces per gram dry matter (DM) was then calculated. The percentage of digestible energy (DE) in the ration was calculated by expressing the difference in average daily total energy between feed and faeces as a percentage of energy intake. Energy digestibility per feed unit was determined as the difference between feed energy consumed and the amount of energy excreted in the faeces per unit of dry matter intake (DMI).

A 5 ml urine sample dried in a plastic bag of known energy content was used in determining urine energy. The urine samples together with sponges soaked in a saturated clacium chloride solution and dried at 100°C were placed in a vacuum oven at −22 mm mercury pressure until the urine samples were dry. The percentage of metabolizable energy (ME) in the ration was then determined as the difference between feed energy intake and the excretion of energy in the faeces and urine expressed as a percentage of energy intake.

Growth and carcass composition trial

Twenty pigs divided according to sex, live-weight and liter origin into two comparable groups of 10 each were used. The feeding method employed was the same as that used in the metabolism trial.

The pigs were all fed to a final weight of between 85 and 90 kg. Pigs were slaughtered only one day each week – 24 hours after they had attained the desired weight. The carcass was kept in cold storage for 48 hours after which it was weighed to obtain its cold carcass weight. The carcass was then suspended by the hind legs and, after removal of the head, split medially down the back and the following measurements taken on the left side:–

1. Length of carcass from the anterior edge of the symphysis pubis to the anterior edge of the first rib.

2. Backfat thickness (including rind) at the following points:–

   (a) over the anterior, middle and posterior positions of the rump muscle (*m. gluteus medius*);

   (b) at mid-back in the region of the last thoracic vertebra where the backfat is thinnest;

   (c) at the thickest point over the shoulder.

The left side was then cut transversely between the last thoracic and first lumbar vertebrae and the C and K fat measurements measured over the exposed eye-muscle, at points respectively 4.5 and 9.0 cm from where the carcass was medially split.

The right side of each of five carcasses in each group was put through a Wolff King mill, ground five times and sampled. After freeze drying the sample, it was mixed with about five times its volume of dry ice and finely ground in a Willey mill whereafter a sample was taken for chemical analysis and stored in air-tight containers in a deep freeze until analyzed. Moisture, nitrogen, ether extract and ash was determined according to A.O.A.C. (1955) methods.

Results and Discussion

The composition of ingredients used in compiling the experimental ration is given in Table 3.

Table 3

Composition of ration ingredients

		Yellow maize meal	Lucerne meal	Wheaten bran	Fish meal
Moisture	g/100g	12,35	9,46	10,04	5,61
Crude-protein**	g/100g	8,79	15,59	14,02	66,14
Crude-fibre**	g/100g	2,02	24,27	11,25	0,28
Ash**	g/100g	1,24	11,14	4,58	13,45
Ether extract**	g/100g	3,79	1,45	33,63	4,04
Gross energy**	g/100g	4040,1	3852,8	4107,5	4749,8
Lysine**	g/100g	0,28	0,67	0,44	4,19
Histidine**	g/100g	0,28	0,35	0,30	1,49
Threonine**	g/100g	0,27	0,70	0,36	2,28
Valine**	g/100g	0,49	1,11	0,54	3,11
Methionine**	g/100g	0,23	0,32	0,13	1,68
Leucine**	g/100g	0,96	1,27	0,69	4,20
Isoleucine**	g/100g	0,30	0,76	0,40	2,61
Tyrosine	g/100g	0,24	0,34	0,23	1,41
Phenylalanine**	g/100g	0,38	0,68	0,34	2,09

**In the air-dry matter of each component.

In general the data obtained compares favourably with that of other workers (NRC, 1968; van der Merwe, 1967; Haugse & Dinnussen, 1969; Wiechers & Laubscher, 1962; Brock, 1964; de Meulenaere & Quicke, 1959; von Fintel & Quicke, 1962; Hubbell, 1970). The amino acid content of the wheaten bran and especially that of the fish meal is however lower than that obtained by other workers. Only Florence (1965) reported fish meal to contain less than 4% lysine.

The protein and amino acid content of the experimental ration as fed to the pigs during the two metabolism trial periods is tabulated in Table 4.

Digestibility data obtained with restricted and *ad lib.* fed pigs were combined as the amount of feed fed had no influence on the resultant data (Tables 4 and 5). There was only a slight difference in the crude protein and amino acid content of the two separately mixed mixtures (Table 4). The amino acid content of the ration compares favourably with that recommended by the ARC (1967), NRC (1968) and Robinson & Lewis (1963) for porker type rations. It would however be advisable to determine the trytophan content of such a ration as fish meal has a low content while the contribution of the main ration constituent, maize, is very small. The differences in digestible protein (80,8% for Mixture I and 86,3% for Mixture II) and in the digestibility of the individual amino acids in favour of Mixture II must be attributed to the fact that the pigs were older and heavier when fed Mixture II. A similar trend was observed by Dammers (1964). Table 5 summarizes the data on the energy content of the experimental ration.

Table 4

Protein and amino acid composition of ration

	Experimental ration: Mixture I***	C.V. ± %	Mixture II***	C.V. ± %
Crude protein** %	17,38		17,16	
Digestible protein** %	14,05		14,80	
Amino acids as % of ration:– **				
Lysine	0,88		0,88	
Histidine	0,45		0,48	
Threonine	0,69		0,60	
Valine	0,93		0,91	
Methionine	0,44		0,45	
Isoleucine	0,72		0,75	
Leucine	1,60		1,56	
Tyrosine	0,47		0,43	
Phenylalanine	0,69		0,67	
Digestibility of amino acids:– **				
Lysine	83,8	3,6	88,5	2,7
Histidine	89,0	2,1	92,9	1,8
Threonine	83,1	3,6	83,5	5,0
Valine	82,8	4,0	86,7	3,0
Methionine	84,8	3,1	90,1	2,3
Isoleucine	81,0	4,9	87,9	2,6
Leucine	85,9	2,8	90,4	3,0
Tyrosine	84,0	3,6	89,1	3,7
Phenylalanine	83,5	3,8	89,2	3,6

**In the air-dry matter in the diet. Diet contained 89,7 and 89,4% D.M. respectively.

***Pigs fed Mixture I weighed 41,7 kg on average when removed from the metabolism crates, while the pigs fed Mixture II weighed 72,6 kg.

Table 5

Energy content of the experimental ration on a moisture free basis

	Experimental ration: Mixture I	C.V. ± %	Mixture II	C.V. ± %
Gross energy, Mcal/kg	4,52		4,51	
Digestible energy, Mcal/kg*	3,62		3,70	
Metabolisable energy, Mcal/kg**	3,47		3,51	
Energy digestibility:–				
%D.E.	80,1	2,2	82,0	2,7
%M.E.	76,9	5,0	77,8	3,4
%TDN	82,0	4,5	83,9	2,0
%D.D.M.	81,0	2,7	82,3	2,3
ME expressed as a % of DE	96,0		94,9	
DE expressed as a % of DDM	98,9		99,6	
DE expressed as a % of TDN	97,7		97,7	
ME expressed as a % of TDN	98,8		92,7	
DDM expressed as a % of TDN	98,8		98,1	
ME expressed as a % of DDM	94,9		94,5	

*Air-dry diets have 3,25 and 3,28 Mcal DE/kg of feed for Mixtures I and II respectively.

**Air-dry diets have 3,11 and 3,12 Mcal ME/kg feed for Mixtures I and II respectively.

The DE and ME content of the ration (Table 5) is somewhat higher than the 3,1 to 3,5 Mcal DE/kg DM recommended for growing pigs by the ARC (1967) and the NRC (1968). The ME content of the ration averages 96,0 and 94,9 per cent of the DE content which is slightly higher than the figure of 94,7 reported by Diggs, Becker, Jensen & Norton (1965). It is, however, significant to note that the NRC (1968) formula used in converting DE to ME whereby ME (Kcal/kg = DE (Kcal/kg x $(96 - \frac{0,202 \text{ x prot.} \%}{100})$ yields very accurate results when used to convert DE to ME in the present study.

Although the calorie value of TDN is not constant it averages very close to 4,5 kcal/g TDN according to Crampton, Lloyd & MacKay (1957) and Zivkovic & Bowland (1963). In the present study a comparable value of 4,41 was found, thus suggesting that this figure could be used when converting TDN to DE. The formula used by the NRC (1968) whereby DE (kcal/kg) = $\frac{\text{TDN} \%}{100}$ x 4409,2 also gives accurate values when applied to the data presented in Table 5. From the data presented it is evident that there is a close resemblance between the percentage DDM and the percentage DE in the ration. Zivkovic & Bowland (1963) found a similar relationship and consequently suggested that when less critical data is required, dry matter digestibility, which is relatively easily determined, could give a good indication of energy digistibility.

The average growth, feed utilization and carcass composition of pigs fed the experimental ration in the growth and carcass composition trial are shown in Table 6.

Table 6

Average growth, feed utilization and carcass composition of pigs fed the experimental ration

Treatment		Pigs restricted throughout trial period	Pigs fed *ad lib* to 50 kg live-weight and then restricted
Initial weight	kg	24,1	23,4
Slaughter weight	kg	87,2	86,9
Average daily gain kg: –			
1) Initial to 50 kg live-weight		0,553	0,625
2) 50 kg to slaughter		0,577	0,584
3) Entire trial period		0,568	0,607
Feed utilization, kg feed/kg gain:			
1) Initial to 50 kg live-weight		2,59	2,76
2) 50 kg to slaughter		3,76	4,00
3) Entire trial period		3,23	3,42
Carcass characteristics: –			
Dressing percentage		78,3	78,9
Carcass length mm		794,0	792,0
Average backfat thickness mm		29,0	29,8
C + K fat measurement mm		43,6	44,2
Eye-muscle A measurement mm		81,2	79,3
Eye-muscle B measurement mm		49,1	48,5
Eye-muscle area sq. cm		29,2	28,6
Carcass composition:			
1) Fat %		60,9	63,4
2) Protein %		32,8	30,9
3) Ash %		6,5	6,3

The pigs initially fed *ad lib.* grew faster than the restricted group up to a live-weight of 50 kg (Table 6). Although they maintained a slight advantage in growth rate when fed an equal amount of feed after 50 kg live-weight the overall average daily gain in weight between the two groups was insignificant. The pigs restricted throughout the experimental period had a better feed conversion ration, less back fat, larger eye muscles and less fat and more protein in the DM of the carcass. All these differences were however small and statistically non-significant ($P<0,05$). The only justification for unrestricted feeding during the porker phase can thus be found in the fact that the higher feed intake resulted in the pigs reaching market weight 6.3 days sooner than their restricted counterparts, which was not statistically significant.

The growth rate, feed conversion and carcass measurements of the two experimental groups compare favourably with those of other South African workers (Pieterse & Penzhorn, 1960; Florence, 1965; Kemm, Minnaar & Bonsma, 1969). Similar carcass measurements but a faster growth rate (0,732 kg/day) and a better feed conversion ratio (3,11) is reported for pigs tested under the National Pig Testing Scheme (1970). The faster growth rate of the Testing Scheme pigs could be attributed to a higher feed intake (they are fed *ad lib.* for two twenty minute periods a day), to the fact that they are put on test only after attaining a live-weight of 31,8 kg and due to there being only four pigs per group. While the size of the groups and the fact that the ration is pelleted could have had a beneficial influence on the feed conversion ratio.

The feed, DE and ME intakes on an air-dry basis of the pigs in the growth trial is presented in Tables 7 and 8.

Table 7

Feed and energy intake of the restricted group of pigs on an air-dry basis

Weight of pig	Feed/day*	DE/day*	ME/day*
kg	kg	Mcal	Mcal
27,3	0,900	2,925	2,799
30,0	1,000	3,250	3,110
33,3	1,205	3,916	3,748
37,3	1,332	4,329	4,143
42,1	1,695	5,509	5,272
46,4	1,795	5,834	5,583
51,2	2,086	6,780	6,488
55,3	2,059	6,692	6,404
59,3	2,201	7,153	6,845
60,8	2,004	6,513	6,232
68,9	2,156	7,007	6,705
72,3	2,181	7,088	6,783
76,2	2,236	7,267	6,954
79,5	2,273	7,387	7,069

*Data calculated on the values given for Mixture I in Table 5 for air-dry DE, ME and moisture content.

The actual intake of air-dry feed by the pigs restricted in their feed intake (Table 7) is well below the levels recommended by both the ARC (1967) and the NRC (1968). Until they were restricted after attaining a weight of 50 kg the feed intake of the *ad lib.* fed group (Table 8) was very similar to that recommended by the ARC (1967) but lower than that suggested by the NRC (1968). Due to the high DE content of the experimental ration the DE intake of the *ad lib.* fed pigs (Table 8) was slightly higher than the accepted ARC standard but again very much lower than NRC values.

Table 8

Feed and energy intake of the ad lib *fed group of pigs on an air-dry basis*

Weight of pig	Feed / day *	DE / day *	ME / day*
kg	kg	Mcal	Mcal
27,6	1,245	4,046	3,561
31,4	1,418	4,609	4,410
36,4	1,668	5,421	5,188
40,4	1,823	5,925	5,670
45,4	2,141	6,958	6,659
49,7	2,064	6,708	6,419
54,1	2,273	7,387	7,069

*Data calculated on the values given for Mixture I in Table 5 for air-dry DE, ME and moisture content.

The feeding schedules followed yielded carcasses that comply favourably to local grading regulations and market demand. Consequently it is felt that feed intake when restricted to a maximum of 2,27 kg (7,4 Mcal DE) per day ensures the production of high quality carcasses without severely retarding growth rate. The results attained at the National Progeny Testing Stations Pig Testing, Fourth Report (1969/70) do however suggest that further evidence is needed before a maximum daily feed intake figure can be laid down for baconers between 50 and 90 kg live-weight.

In conclusion it is felt that the information gained in the evaluation of the experimental ration, composed of locally available ingredients, can be used as a basis for laying down nutrient requirements for pigs. A great deal of work must however still be done as no attention has as yet been given to the nutrition of the sow and the pre- and early weaned piglet. Data on the composition of locally available feedstuffs is with a few exceptions (fish meal) virtually non-existent thus emphasising the need for extensive analyses of South African feedstuffs.

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