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THE USE OF SOUTH AFRICAN BRED *OPAQUE-2* MAIZE IN PIG GROWTH DIETS

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OPSOMMING: DIE GEBRUIK VAN *OPAQUE-2* MIELIES, IN SUID-AFRIKA GETEEL, IN VARKGROEIMELE

Die doel van hierdie studie was om (1) *opaque-2* (of hoë-lisien) mielies, in Suid-Afrika geteel, te vergelyk met gewone mielies in varkdiëte met 'n ekwivalente sub-optimum proteïeninhoud en om (2) die proteïenbesparende effek van 'n *opaque-2* mielie bevattende dieet te bepaal wanneer dit op 'n lisien ekwivalente basis vergelyk word met 'n dieet wat met gewone mielies en vismeel saamgestel is. Ses-en-dertig Landras x Grootwit beertjies, aanvanklik 20 kg in massa, is een van 3 proefdiëte toen *ad libitum* -inname gevoer in 'n latynse vierkant oorslag proefontwerp, oor 'n tydperk van 9 weke. Dieet 1 (14% ruproteien, gewone mielies), Dieet 2 (14% ruproteien, *opaque-2* mielies) en Dieet 3 (15% ruproteien, standaarddieet, gewone mielies, hoër vismeelinhoud), met lisieninhoude van 0,711%, 0,802% en 0,828%, respektiewelik en 'n ekwivalente ME-inhoud van ongeveer 13 MJ/Kg, is gebruik. Die dieet met 'n lae proteïeninhoud waarin gewone mielies gebruik is, het massatoenames getoon wat hoogsbetekenisvol laer was (tussen 8,1 en 9,7%) as die ander twee diëte, wat nie van mekaar verskil het nie. Hierdie dieet het ook die doeltreffendheid van voerverbruik betekenisvol met tussen 6,9 en 7,9% verminder. Verder is ook vasgestel dat die hoeveelheid vismeel in die dieet met 22% verminder kan word sonder dat die prestasie van die vark benadeel word indien *opaque-2* mielies in plaas van gewone mielies gebruik word. Al hierdie bevindings het duidelike ekonomiese implikasies in varkvoeding.

SUMMARY

The purpose of this study was (1) to compare South African bred *opaque-2* (or high lysine) maize with normal maize in pig diets that contain an equivalent sub-optimum protein percentage and (2) to determine the protein sparing effect of a diet containing *opague-2* maize when compared on a lysine equivalent basis with a diet containing normal maize and fish meal. Thirty six Landrace x Large White boars, initially 20 kg in mass, were fed *ad libitum* one of three experimental diets in a latin square crossover experimental design over a 9-week period. Diet 1 (14% crude protein, normal maize), Diet 2 (14% crude protein, *opaque-2* maize) and Diet 3 (15% crude protein, standard diet, normal maize, higher fishmeal content) with lysine contents of 0,711%, 0,802% and 0,828%, respectively, and an equivalent ME-content of 13 MJ/Kg, were used. Pigs fed the low protein, normal maize diet gained highly significantly less (between 8,1 and 9,7%) than pigs fed the other 2 diets which did not differ from each other. This diet was also less efficiently utilised than the other 2 diets to the extent of 6,9 to 7,9%. It was also established that 22% less fish meal can be used in the diet without influencing pig performance if *opaque-2* instead of normal maize is used. These findings have clear economic implications in pig feeding.

Quality protein or high lysine maize, as considered here, derives genetically from the action of the recessive endosperm mutant *opaque-2*, which has been widely characterised in recent years in terms of its biochemical and physical effects in the maize kernel, particularly the endosperm fraction (Mertz, Bates & Nelson, 1964; Alexander, 1966 and Gevers, 1972).

The nutritional advantage of *opagque-2* maize can be ascribed to an improved amino acid balance and particularly to increases in the lysine and tryptophan content (Klein, Beeson, Cline & Mertz, 1971, 1972; Maner, Pond, Gallo, Henao, Portela & Linares, 1971; Gipp & Cline, 1972 and Quicke & Gevers, 1972).

The substitution of *opaque-2* maize for normal maize in diets with sub-optimal protein levels results in improved gains and feed conversion ratios of growing pigs (Gallo, Maner & Jiménez, 1968 and Kornegay, Hedges, Webb, Thomas, Baker, Carlisle, Harmon & Jensen, 1975).

Kornegay *et al.* (1975) found the lysine in *opaque-2* maize to be as available as that in normal maize when fed to growing pigs. Pig performance in growth and feed utilisation was directly related to the lysine content of the maize. Their study indicated that pigs fed diets with a total lysine content of 0,78% performed similarly although the protein conteint of the diets varied between 13,3 and 16%. On the contrary pigs fed a 14% protein diet, but with only 0,64% lysine, had a significantly slower growth rate (13%) and a worse feed conversion efficiency (5%).

Consequently "high lysine" maize can be used to save protein. It is therefore important to compare South African *opaque-2* maize varieties with local normal maize varieties in pig diets formulated with feedstuffs available in South Africa. A comparison of this nature was deemed necessary due to the fact that the American work, mentioned above, is based on diets made up of maize and soyabean meal, while South African pig diets contain mainly fish meal as protein source and wheaten bran or lucerne meal as fibre rich components. As a result the amino acid pattern of South African diets differ from the American diets, particularly in lysine, tryptophan, methionine and cystine, which in fact are of the first amino acids to become limiting in pig diets.

Quicke (1974) and du Preez, Gevers, Quicke & Gous (1974) have already indicated that the protein quality of South African *opaque-2* maize is better than that of normal maize in experiments with rats and

chickens. Since net protein utilisation (NPU) and protein efficiency ratio (PER) were used as criteria of protein quality, these studies cannot be used to establish the supplemental value of normal maize with *opaque-2* maize in practical pig diets.

The purpose of this study was to compare experimental South African *opaque-2* hybrid maize with normal maize in pig diets with an equivalent sub-optimum protein content. A further aim was to establish the protein sparing effect of a diet containing *opaque-2* maize, when compared on a lysine equivalent basis, with a standard diet composed of normal maize and fish meal.

Material and procedure

Thirty six male Landrace x Large White crossbred pigs were used in the experiment.

The *opaque-2* maize used in the diets was the experimental white double cross hybrid N05101 bred at the Summer Grain Sub-Centre at Pietermaritzburg and produced at the Ukulinga Research Station during the 1975–76 season. Analyses of whole grain material carried out gave mean crude protein and lysine figures (air-dry) of 9,22 and 3,60% , respectively, the latter figure being expressed as a percentage of the protein. Corresponding figures for the normal yellow maize used in the diets were 8,76% protein and 2,10% lysine.

Three experimental diets (Table 1) were used because Kornegay *et al* (1975) found growth and feed utilisation ability to be directly related to the lysine content of the diet irrespective of the protein content, for diets with a protein content between 13,3 and 16%. Diets 2 and 3 were thus composed to have an identical lysine content, sufficient by ARC (1967) standards, but different in protein content, in order to establish the protein sparing effect of *opaque-2* or high lysine maize. Furthermore, Diets 1 and 2 were composed to differ only in the type of maize used in order to compare *opaque-2* maize with normal maize when fed in diets with a sub-optimum protein content.

Table 1

Experimental diets

	Number of diet		
	1	2	3
Yellow maize meal (normal maize), %	72	0	72
Opaque-2 (high lysine) maize meal, %	0	72	0
Lucerne meal, %	8	8	9
Wheaten bran, %	10	10	6,75
Fish meal, %	8	8	10,25
Bone meal, %	1	1	1
Salt, %	1	1	1
Minerals + Vitamins, a commercial mixture	+	+	+
Protein content of diet*, %	14,09	14,34	15,09
Lysine content of diet&, %	0,711	0,802	0,829
ME content of diet*, MJ/kg feed	12,98	12,93	13,18

*On an air dry basis

Pigs were allotted to one of the three dietary treatments on attaining a live mass of 20 ± 0,4 kg. The animals were individually kept in cages (1,5 x 1 metre) fitted with automatic water nipples and a self feeder to which they had unlimited access.

Live mass and feed intake were measured every third day without withholding water and food from the animals. Pigs were fed a specific treatment for 21 days and then switched to one of the other 2 treatments for a further 21-day period.

After completing a 21-day period on a specific diet, each of 6 groups consisting of 6 pigs each were fed one of the other 2 diets for a further 21 days and then the third diet for a final 21-day period in a Latin square cross-over design (Cochran & Cox, 1968) balanced for residual effects as set out in Table 2.

Table 2

Experimental design balanced for residual effects

Pig group* No.	1	2	3	4	5	6
Period No.	Number of diet fed to group					
1	1	2	3	1	2	3
2	2	3	1	3	1	2
3	3	1	2	2	3	1

* 6 pigs to a group

Adaptation periods of 6 days during the first and 3 days during each of the second and third periods were deemed necessary after plotting the log of cumulative feed intake against the log of live mass according to the method described by Roux (1974). Initial feed intake was derived from unpublished data obtained in another experiment (E. Kemm, 1977, personal communication). Fig. 1 illustrates that the data points mentioned above deviate from the rest, hence the need to ignore them.

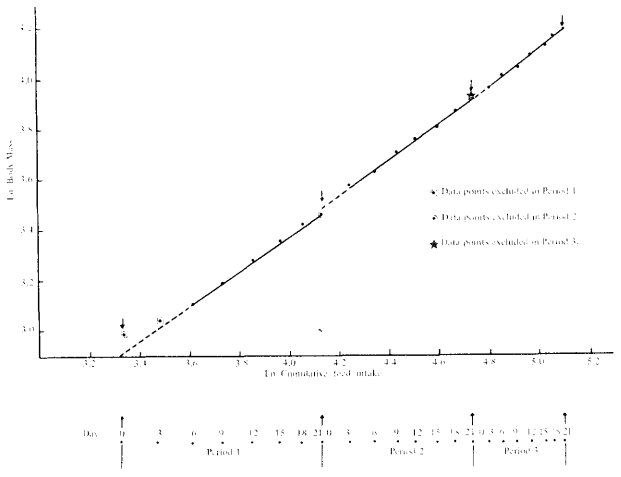

Fig. 1 *A Plot of Ln cumulative feed intake and Ln body mass for one of the experimental pigs, to indicate why adaptation periods were allowed.*

The dietary content of protein, lysine and metabolisable energy (Table 1) was analysed by the following techniques: crude protein AOAC, (1965) and lysine Smith (1977). Metabolisable energy (ME) was determined with 5 pigs per diet in metabolism cages as described by Kemm (1974).

Results

In Table 3 are summarised the separate analyses of variance performed on the experimental data collected while mean treatment effects on the daily feed intake, live mass gain and feed conversion efficiency of the pigs are presented in Table 4.

Table 3

Mean squares from Latin square analyses of variance for estimating residual effects when treatments are applied in sequence

Source of variance	D.F.	Daily feed intake	Daily mass gain	Feed conversion ratio
Animals	35	0,067**	0,008	0,061
Periods	2	2,883**	0,160**	0,816**
Treatment effects (unadjusted)	2	0,003	0,043**	0,563**
Residual effects (adjusted)	2	0,019	0,002	0,071
Residual effects (unadjusted)	2	0,022	0,004	0,010
Treatment effects (adjusted)	2	0,0003	0,041**	0,624**
Error	66	0,016	0,006	0,063
Total	107			

**Statistically significant at P 0,01.

Table 4

Mean performance data of pigs fed growth diets with normal or opaque-2 maize

Diet No.		1	2	3
Protein in diet, % (Approx.)		14	14	15
Maize type		Normal	Opaque-2 (High lysine)	Normal
Period 1				
Initial pig mass	kg	23,0	23,9	23,5
Feed consumed per day	kg	1,70	1,72	1,71
Daily gain in live mass	kg	0,616	0,678	0,676
	%	100	109,7	109,7
Feed consumed/kg gain,	kg	2,77	2,56	2,55
	%	100	92,4	92,1
Period 2				
Initial pig mass,	kg	36,2	35,0	35,1
Feed consumed per day	kg	2,04	2,06	2,05
Daily gain in live mass	kg	0,713	0,773	0,773
	%	100	108,4	108,4
Feed consumed/kg gain	kg	2,89	2,68	2,67
	%	100	92,7	92,4
Period 3				
Initial pig mass,	kg	51,8	51,4	51,7
Feed consumed per day	kg	2,27	2,28	2,27
Daily gain in live mass,	kg	0,744	0,804	0,804
	%	100	108,1	108,1
Feed consumed/kg gain,	kg	3,06	2,85	2,84
	%	100	93,1	92,8

Feed intake

The treatment imposed had no effect on the daily intake of the pigs (Table 3). However, a highly significant ($P < 0,01$) animal and period effect on feed intake ability was observed.

Live mass gain

The differences in live mass gain between Treatment 1 and the other two treatments (8,1 to 9,7%) were statistically highly significant ($P < 0,01$). It was also found that pigs gained at a highly significantly ($P < 0,01$) faster rate in a subsequent experimental period (Tables 3 and 4).

Feed utilisation

Both the period during which the pig was fed as well as Treatment 1 (Diet 1) had a highly significant ($P < 0,01$) effect on the feed utilisation ability of the pigs (Table 3). Feeding Diets 2 and 3 (Treatment 2 and 3) improved feed utilisation by 6,9 to 7,9% over that achieved by the pigs fed Diet 1 (Table 4).

Discussion and conclusion

In this experiment substitution of normal maize with *opaque-2* maize improved growth rate by between 8,1 and 9,7% and efficiency of feed utilisation by 6,9 to 7,6% when fed at a dietary protein content of about 14% to growing pigs (Table 4). From Table 1 it can be seen that the two diets (Diets 1 and 2) are equal in both protein and ME content, but differ in lysine content (0,711 and 0,802% lysine, respectively). Furthermore, it is apparent from Table 4 that animals fed Diets 1 and 2 consumed a similar daily amount of food. It is therefore obvious that pig performance was influenced by the quality of the proteins in the diet, in particular the lysine content. This is further substantiated by the performance of the pigs fed Diet 3. Although these pigs were fed a diet with a higher protein content (table 1), their performance was identical to that of Diet 2 pigs, thus indicating that dietary lysine content could most probably have been the determining factor.

The results of this experiment are therefore in full agreement with those of Kornegay *et al* (1975) who found feedlot performance to be directly related to the lysine content of the diet in *opaque-2* maize evaluation studies.

The fact that the dietary content of lysine plays an important role in the performance of the growing pig is further substantiated by the fact that the supplementation of synthetic lysine as such greatly influences the performance of growing pigs when added to lysine deficient diets with a protein content that varies between 10 and 15% (Braude, Mitchell, Myres & Newport, 1972; Batterham, 1974; Baker, Katz & Easter, 1975; Henry & Bourdon, 1976 and Szelényi-Galántai, Jécsai & Juháza, 1975).

It is also important to note that the use of *opaque-2* maize resulted in a marked saving of supplemental protein (fish meal in this experiment). Similar results were achieved with Diets 2 and 3 inspite of the fact that Diet 2 had 22% less fish meal than Diet 3. American work, quoted by Maner (1975), furthermore shows that higher lysine varieties of *opaque-2* maize can be used as the only dietary source of protein during the finishing, pregestation and gestation periods of a pig's life cycle without reducing performance.

These findings have obvious economic implications particularly as a considerable saving in fish meal is indicated. The economic advantages of *opaque-2* maize in pig feeding will expectedly be greatest if the grain yields of *opaque-2* hybrids are at least equal to those of the commercial normal hybrids in use today and otherwise do not present serious production hazards. In a recent review of the progress made in *opaque-2* maize breeding, Gevers (1977) suggests that there are no insurmountable problems in attaining these goals. However, even greater potential benefits may be expected in the future if the protein content *per se* of *opaque-2* maize were to be raised by breeding to a level higher than the 9,23 recorded for the experimental maize used in this experiment.

In a report on the protein requirements of the South African livestock industry during 1980, Cloete (1976) concludes that our livestock industry may be in a serious situation by 1980 unless drastic measures are applied immediately to increase protein production for animal feeding. It can therefore be concluded that the advantages of *opaque–2* or quality protein maize must be fully exploited in pig feeding as soon as it is produced economically in South Africa.

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