S. Afr. J. Anim. Sci. 12, 135 – 142 (1982)

AN EVALUATION OF HIGH LYSINE MAIZE IN THE DIETS OF BROILERS

Receipt of MS 23–03–1982

R.M. Gous and H.O. Gevers*

Department of Animal Science and Poultry Science, Faculty of Agriculture, University of Natal, Pietermaritzburg

(Key words: *High lysine maize, broiler diets, pigmentation)*
(Sleutelwoorde: *Hoë lisien mielies, braaikuiken diëte, pigmentasie)*

OPSOMMING: EVALUASIE VAN HOË LISIEN MIELIES IN BRAAIKUIKEN DIËTE

Die voedingswaarde van hoë lisien mielies in vergelyking met gewone mielies in die diëte van braaikuikens is in 2 proewe met 2400 kuikens in elke proef bepaal. Alhoewel daar geen betekenisvolle verskille in massatoename of voerinname in die eerste proef was nie, het die kuikens wat hoë lisien mielies ontvang het nogtans beter presteer as dié wat die gewone variëteit ontvang het. Wit hoë lisien mielies was beter as die geel variëteit in hierdie proef. Die tweede proef is beplan om die hoeveelheid sintetiese karotenoïede wat benodig is vir 'n aanvaarbare vleiskleur by braaikuikens wat met hoë lisien mielies gevoer is te bepaal. 'n Vergelyking word aangegee waarmee die hoeveelheid bepaal kan word. Die resultate van die twee proewe het aangedui dat terwyl geel hoë lisien mielies die aanbevole mielievariëteit in diëte vir braaikuikens sou wees, die voortreflikheid van hierdie variëteit bo gewone geel mielies nie so duidelik as by diëte vir varke is nie.

SUMMARY:

The feeding value of high lysine maize compared with normal yellow maize in the diets of broiler chickens was evaluated in 2 experiments using 2400 chickens in each trial. In the first experiment, although no differences in mass gain or food intake were significant, nevertheless broilers fed high lysine maize performed better than those fed the normal variety. White high lysine maize was superior to the yellow variety in this experiment. The second experiment was designed to determine the amount of synthetic Carotenoids needed to produce acceptable flesh colour in broilers fed white high lysine maize. An equation is presented from which it is possible to determine this amount. The results of the two trials indicate that whilst yellow high lysine maize would be the most favourable maize variety in diets for broilers, the superiority of this variety over normal yellow maize is not as evident as in diets for pigs.

The main cereal used in diets for poultry in South Africa is yellow maize. The Department of Agriculture and Fisheries has developed maize cultivars that have an improved nutritional value over the maize being produced at present. A white high lysine maize hybrid, HL 1, is already commercially available, whilst a yellow hybrid, which has also been developed and is nutritionally similar to the white variety, is to be made available in the near future. In order to fully utilise the improved white variety in diets for broilers and laying hens it is necessary to supplement the diet with synthetic carotenoids so as to ensure adequate carcass and egg yolk pigmentation. This is not required in the case of the yellow hybrid.

The purpose of this study was two-fold. Firstly, the 3 varieties of maize, namely, standard yellow maize, white and yellow high lysine maize, were used in diets fed to broilers during the finisher (21 to 42 d of age) period in order to evaluate biologically the value of these varieties. Secondly, a pigmentation study was conducted, the purpose being to ascertain at what level synthetic Carotenoids should be included in the diets of broilers in order to produce acceptable pigmentation of the skin when white high lysine maize is used in such diets.

Experimental Procedure

Experiment 1

2400 three-week-old Ross broilers were used in this experiment. They were kept in an experimental unit in which light, temperature and ventilation could be controlled. Artificial lighting was supplied for 23 hours each

* Grain Crops Research Institute, Department of Agriculture and Fisheries, P.O. Box 375, Pietermaritzburg, 3200

day, the intensity being kept to a low level, this being consistent with commercial broiler management practice. Food and water were supplied *ad libitum.* The broilers were housed in 24 pens of 100 birds each, males and females being reared separately.

Body mass of the birds in each pen was measured at the start of the trial (21 days of age) and again 21 days later when the experiment was terminated. Food consumption per bird was calculated from records of food allocated during the trial, food remaining at the end of the trial and the days on which mortality occurred.

Table 1

Composition (g/kg) of the two basal diets used in Experiment 1

Ingredient	Basal Diet [1]	
	1	2
Pollard	113,1	199,2
Groundnut oilcake meal	146,5	
Fishmeal	548,2	502,0
Poultry by-product meal	144,8	243,7
Lysine – HC1	3,3	
DL-Methionine	4,1	4,9
Limestone	40,0	44,1
Monocalcium phosphate		4,5
Salt		1,6
Vitamin and mineral premix	+	+
Coccidiostat	+	+
Calculated analysis [1]		
ME (MJ/kg)	13,60	13,60
Protein (N x 6,25/kg)	19,53	20,02
Lysine (g/kg)	1,02	1,02
Methionine (g/kg)	0,47	0,47

1 Analysis assumes a mixture of 245 parts Basal 1 + 755 parts yellow maize meal; and 245 parts Basal 2 + 755 parts high lysine maize meal.

Two basal diets were formulated using a least-cost linear programming technique, one diet containing standard yellow maize, whereas in the second diet the standard maize was substituted with an equal proportion of high lysine maize. The composition of these 2 basal diets is given in Table 1. Because the "protein concentrate" portion of the 2 basal diets differed one from the other, any differences in growth or food conversion efficiency could have been attributed to differences in the concentrate and not to the varieties of maize used in the trial. Consequently the number of dietary treatments was increased to include diets in which the standard maize was fed with the high lysine maize concentrate and *vice versa.* Also, 2 types of high lysine maize were tested, a white and a yellow variety. There were thus 6 dietary treatments as detailed in Table 2. Each dietary treatment was fed to 2 pens of male broilers and 2 pens of female broilers.

Table 2

Blending proportions (percent) of the six dietary treatments used in Experiment 1

Diet	Basal 1	Basal 2	YMM [1]	WHLM [2]	YHLM [3]
1	24,5		75,5		
2	24,5			75,5	
3	24,5				75,5
4		24,5	75,5		
5		24,5		75,5	
6		24,5			75,5

1 Yellow maize meal
2 White high lysine maize meal
3 Yellow high lysine maize meal

Experiment 2

The purpose of this experiment was to ascertain at what level synthetic carotenoids should be included in the diets of broilers in order to produce acceptable pigmentation of the skin when white high lysine maize is used in such diets.

2400 Hybro broilers were used, the trial in this case starting when the chickens were one day old and continuing to 49 days of age. Management practices and housing conditions were similar to those used in the first experiment.

Five basal diets were used in this trial: a starter diet containing white high lysine maize fed to all birds, except those on Treatment 1, to 21 days of age; 2 finisher diets, one containing standard yellow maize meal, the other containing white high lysine maize; and 2 post-finisher diets also containing either standard yellow maize or white high lysine maize. The composition and calculated analysis of these 5 diets is given in Table 3. In formulating the 2 finisher and 2 post-finisher diets emphasis was

Table 3

Composition (g/kg) and calculated analysis of diets fed in Experiment 2

Ingredient	Starter diet	Finisher YMM	Finisher HLM	Post-finisher YMM	Post-finisher HLM
Yellow maize		610,0		687,0	
High lysine maize	750,0[1]		805,0		845,0
Fishmeal	155,0	129,0	143,0	129,0	130,0
Sunflower meal	66,0	69,0		55,0	
Groundnut meal	13,0	62,0	37,0		8,0
Ricebran		122,0		120,0	
Limestone	11,4	7,4	10,3	7,6	11,1
Monocal-phosphate	3,1		2,7	0,6	4,2
Salt	1,2		1,6		1,3
DL-Methionine	0,3	0,6	0,4	0,8	0,4
Vitamin/minerals	+	+	+	+	+
Coccidiostat	+	+	+	+	+
Calculated analysis					
ME (MJ/kg)	13,31	13,68	13,68	13,81	13,81
Protein (N x 6,25/kg)	200,0	208,0	170,5	189,0	153,6
Lysine (g/kg)	11,2	10,4	10,4	9,5	9,5
Methionine (g/kg)	5,3	4,7	4,7	4,6	4,6

[1]Replaced by standard yellow maize meal in Treatment 1

Table 4

Dietary treatments imposed during the three periods of growth in Experiment 2

Dietary treatment	Period (days) 0 – 21	22 – 39	40 – 49
1	YMM [1]	YMM	YMM
2	HLM [2]	YMM	YMM
3	HLM	HLM	HLM
4	HLM	HLM	HLM + 390 C [3]
5	HLM	HLM	YMM + 220 C
6	HLM	YMM	YMM + 115 C
7	HLM	HLM	HLM + 320 C
8	HLM	HLM	YMM + 180 C

1 YMM = standard yellow maize meal
2 HLM = white high lysine maize meal
3 C = mg CAROPHYLL yellow/kg diet

placed on obtaining diets with the same lysine and methionine contents within each period rather than equalising the protein concentration of each diet.

Carotenoids are apparently utilized more efficiently when fed for a relatively short period prior to slaughter than when fed throughout the growing period, and for this reason supplementation of the diet with synthetic carotenoids was limited to the post-finisher period (40 – 49 days of age) only. The 8 dietary treatments imposed during the 3 periods of growth are shown in Table 4. These 8 dietary treatments were replicated 3 times, each replication consisting of one hundred chickens, with equal numbers of male and female chickens in each pen.

Body mass of the birds was determined after 21 days (the starter period), 39 days (finisher period) and 49 days (post-finisher period). Food consumed during each period was measured.

At 49 days of age the shank colour of 12 male and 12 female broilers from each pen was measured by comparison with a Roche Colour Fan, and the mean of these values was used as an indicator of pigmentation of the broilers in each pen.

Assays were conducted by F. Hoffman – La Roche & Co Ltd., Basle, Switzerland, on the 8 post-finisher diets fed in the trial to determine the concentrations of lutein, zeaxanthin, total xanthophyll and apo-ester.

Results and Discussion

Experiment 1

Mean body mass gain, food intake and food conversion efficiency for the 21 day experimental period is presented in Table 5, together with the standard errors of treatment means. The overall means for males and for females are given for interest.

No significant differences were apparent in the growth, food intake or food conversion efficiency among any of the individual dietary treatments imposed. There was, however, a marked tendency for broilers to grow more rapidly, to consume more food and to show an improved food conversion efficiency when fed the diets containing white high lysine maize (treatments 2 and 5), than when fed yellow high lysine maize (treatments 3 and 6), these latter broilers performing similar to those fed diets containing standard yellow maize meal (treatments 1 and 4). The overall means of the above 3 combined treatments are given in Table 5 together with the standard error associated with their treatment means.

The economic implications of the above results are of considerable interest. A theoretical study on the economic potential of opaque – 2 maize in the diets of monogastric animals (Nieuwoudt, Bookless, Gevers and Gous, 1972) intimated that high lysine maize was worth around six percent more than standard maize on the basis of its higher essential nutrient concentrations. In the present exercise, the price of the diet based on high lysine maize was R4,53 per metric ton lower than the diet based on standard yellow maize, assuming the same price for both varieties of maize. The fact that broilers performed better on diets containing high lysine maize indicates that the nutrient concentrations in high lysine maize are higher than expected, otherwise performance should have been the same on all diets. Consequently the value of R4,53 per ton of broiler finisher diet, or R6,00 per ton of high lysine maize, would be a conservative estimate of the additional value of this improved maize variety. This confirms the result obtained by Nieuwoudt *et al.* (1978) regarding the value of opaque – 2 maize diets for broilers.

Experiment 2

The gain in body mass over the 49 day period, together with food intake and food conversion efficiency is presented in Table 6. From these results it is apparent that performance was similar on all diets fed during the experimental period. This observation is of considerable interest in that the protein concentrations in the diets based on high lysine maize were considerably lower than in those diets based on standard yellow maize. It follows therefore that the protein of high lysine maize was better utilized than that of standard maize, which indicates the improved balance of amino acids and hence biological value of the former.

Although the protein concentrations of the 2 finisher and 2 post-finisher diets differed depending on the variety of maize used in the diet, the cost advantage of using high lysine maize was not as evident in this experiment as in the previous one. The diets based on high lysine maize were on average R1,50/ton less expensive than those based on standard maize. There was thus a marginal improvement in profitability in this experiment brought about by the substitution of standard maize with high lysine maize, although there was a considerable saving in dietary protein resources.

Pigmentation

Pigmentation of the carcasses from Experiment 2 was measured by comparing the shank colour of 24 birds from each pen with the colours on a Roche Colour Fan. The means of the values obtained are given in Table 7 together with the standard errors of the mean for each

Table 5

Mean body mass gain, food intake and food conversion efficiency (FCE) for the period 21 to 42 days of age in Experiment 10

Treat-ment	Sex	Mass gain (g/bird)	Food intake (g/bird)	F.C.E.
1	M	865,5	2166	0,400
	F	859,5	2159	0,398
	M + F	862,5	2162	0,399
2	M	925,5	2294	0,403
	F	829,5	2180	0,381
	M + F	877,5	2237	0,392
3	M	871,5	2138	0,408
	F	841,0	2082	0,404
	M + F	856,3	2110	0,406
4	M	905,0	2145	0,422
	F	857,5	2139	0,401
	M + F	881,3	2142	0,411
5	M	1012,5	2158	0,469
	F	837,5	2134	0,392
	M + F	925,0	2146	0,431
6	M	878,5	2286	0,384
	F	827,5	2087	0,397
	M + F	853,0	2186	0,390
Mean of:				
All males		910,0	2198	0,415
All females		842,0	2130	0,396
Treatments 1 + 4		871,9	2152	0,405
Treatments 2 + 5		901,3	2191	0,412
Treatments 3 + 6		854,7	2148	0,398
Standard errors of treatment means:				
Diets		31,51	45,61	0,0167
Sex		18,19	26,30	0,0096
Diets x sex		44,56	64,49	0,0236
Maize varieties		22,28	32,25	0,0118

Table 6

Mass gain, food intake and food conversion efficiency (F.C.E.) per bird during the 49 – day period in Experiment 2

Treatment	Mass gain (g/bird)	Food intake (g/bird)	F.C.E.
1	1469	2788	0,527
2	1484	2771	0,536
3	1470	2785	0,528
4	1457	2785	0,523
5	1477	2814	0,525
6	1479	2787	0,531
7	1454	2773	0,524
8	1470	2793	0,526
Standard error of treatment means	26,1	43,3	

Table 7

Shank pigmentation of broilers at 49 days of age as measured by the Roche Colour Fan (values given as mean ± S.E. of mean of 24 observations per pen)

Treatment	Replication 1	2	3	Mean
1	3,708 ± 1,122	4,125 ± 1,035	4,208 ± 1,215	4,014 ± 0,268
2	3,000 ± 0,659	3,292 ± 0,550	3,292 ± 0,806	3,195 ± 0,169
3	0,042 ± 0,204	0,000 ± 0.000	0,000 ± 0,000	0,014 ± 0,024
4	2,958 ± 0,908	3,792 ± 1,021	3,125 ± 0,612	3,292 ± 0,441
5	1,500 ± 1,022	1,958 ± 0,999	1,375 ± 0,495	1,611 ± 0,307
6	3,625 ± 1,740	5,042 ± 1 042	4,417 ± 0,881	4,361 ± 0,710
7	1,000 ± 0,511	0,875 ± 0,612	0,708 ± 0,550	0,861 ± 0,147
8	1,667 ± 0,761	2,667 ± 0,816	2,500 ± 0,780	2,278 ± 0,536

pen and of the mean for each treatment. A wide range of pigmentations was evident between treatments, but the results within treatments showed remarkable similarity, indicating that this method of evaluating pigmentation is sufficiently accurate for such an experiment. Because the birds were housed in an environment into which no natural lighting could penetrate, there was no bleaching of the colour, and this also contributed to the accuracy of the test.

A shank colour of 3,00 Colour Fan units was regarded by the judging panel as representing an acceptable degree of pigmentation. Treatments 1, 2, 4 and 6 therefore produced broilers that were well-pigmented whilst the other dietary treatments produced unacceptable levels of pigmentation.

In Table 8 the results of the assays for lutein, zeaxanthin, total xanthophyll and apo-ester are given, together with calculated intakes of xanthophyll by the birds during the 0 – 39 and the 40 – 49 day periods. A graph of total intake of xanthophyll over the entire growing period vs shank colour is given in Fig. 1. The correlation coefficient derived from these data is 0,905 which is highly significant (a coefficient of 0,834 being necessary for significance at one percent level).

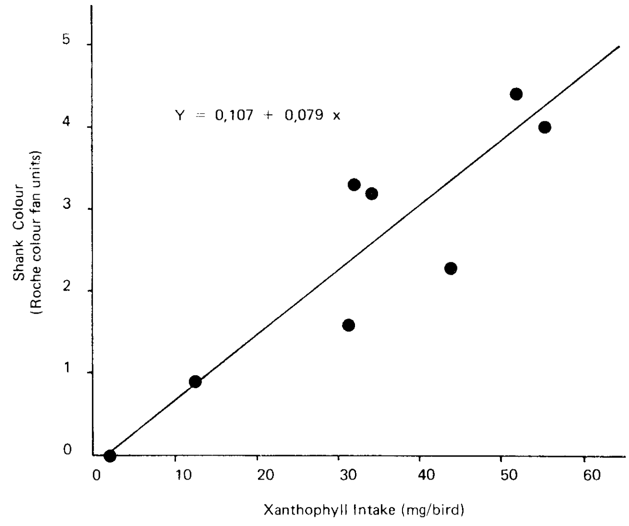

Fig. 1 *Relationship between xanthophyll intake (X) (mg/bird) and shank colour (Y) as measured on a Roche colour fan. The regression equation of Y and X is shown.*

Table 8

*Concentrations * (p.p.m.) of lutein, zeaxanthin, total xanthophyll and apo-ester in the post-finisher diets and intake (g/bird) of xanthophylls during the pre-finisher and post-finisher periods*

Treatment	lutein	zeaxanthin	total xanthophyll	apo-ester	xanthophyll intake 0 – 39 d	xanthophyll intake 40 – 49 d
1	6,1	7,9	18,4		30,0	20,6
2	6,0	7,8	17,6		15,5	18,8
3	0,3	0,5	2,0			2,1
4	0,5	0,7	2,0	28,6		32,3
5	0,0	0,0	1,7	26,2		31,2
6	5,7	7,9	18,1	14,3	15,8	36,2
7	0,4	0,5	1,8	10,0		12,5
8	5,1	8,4	18,2	21,7		44,1

* Values obtained from assays conducted by F. Hoffman, La Roche & Co. Ltd., Basle, Switzerland.

This relationship between xanthophyll intake and broiler pigmentation provides a means of estimating the quantity of xanthophyll needed in a post-finisher diet to supplement the amount previously consumed in order to ensure adequate pigmentation of broilers. The low concentration of Carophyll Yellow in post-finisher diet 7 is difficult to explain, but the pigmentation of broilers fed this diet reflected this low concentration which contributed to the high correlation between intake of xanthophylls and broiler pigmentation.

It can be concluded from these results that, following the feeding of white high lysine maize in the starter and finisher periods, supplementation of this type of high lysine maize with carotenoids in the post-finisher period only can produce adequate pigmentation of broiler carcasses. The level of supplementation needed in the post-finisher diet, assuming an intake of 1 kg per bird during this period, would have to be between 350 and 450 mg Carophyll Yellow per kg diet. In order to reduce this level of supplementation the post-finisher diet could consist of yellow maize plus Carophyll Yellow. The yellow maize would contribute approximately 150 mg xanthophyll per kg diet, thus reducing the required concentration of Carophyll Yellow to between 200 and 300 mg per kg.

High lysine maize has been found to be significantly superior to standard maize in diets fed to pigs (Kemm, 1978). This superiority was not as evident in the experiments with broilers reported here. One possible explanation could be that chickens make better use of the protein of normal maize than do other mongastrics (Du Preez, Gevers, Quicke & Gous, 1974) thereby reducing the difference in the amount of available amino acids between the two maize varieties. Another explanation is that at high dietary protein levels, as used commercially in diets for broilers, slight differences in protein quality are not as evident as would be the case at low dietary protein levels.

Notwithstanding the superiority of white high lysine maize in the diets of broiler chickens, as evidenced by the performance of broilers in Experiment 1, it is difficult to make a case for the inclusion of this variety of maize in commercial diets as the economic advantage is controlled by the cost of carotene supplementation. Yellow high lysine maize, which is soon to be released in South Africa and is essentially equal to the white variety in protein and lysine content (Gevers, unpublished data) would be more economically viable in broiler feeds than both white high lysine maize or standard yellow maize. Although Experiment 1 gave no clear-cut indication of the superiority of yellow high lysine maize over standard yellow maize, its potential has been recognised while an added advantage is that it will not be necessary to supplement the diets with pigmentation agents.

The final decision as to whether white high lysine maize could economically be included in diets for broilers is made comparatively simple with the above data. Once the saving in feed cost has been determined by least-cost feed formulation, the cost of supplementing the diet with Carophyll Yellow can be calculated from the regression equation given in Fig. 1, and this value then multiplied by the current price of Carophyll Yellow. Such decisions will need to be made in the future as the supply and demand for standard yellow maize, white and yellow high lysine maize, fishmeal and soybean oilcake meal change. There is no doubt that the Balanced Feed Industry in South Africa will find it increasingly difficult to meet its requirement for protein in the future – high lysine maize will be of considerable benefit in this regard.

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