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THE EFFECTS OF THREE METHODS OF FOOD RESTRICTION ON GROWTH AND SUBSEQUENT LAYING PERFORMANCE*

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OPSOMMING: DIE INVLOED VAN DRIE METODES VAN VOERBEPERKING OP GROEI EN DIE DAAROPVOLGENDE LÊ-PRESTASIE

'n Totaal van 2400 gemiddelde-tipe henne is gebruik in 'n proef om drie metodes van voerbeperking vanaf twee tot 20 weke ouderdom te vergelyk. Die behandelings het bestaan uit die volgende kwantitatiewe voerbeperkingsbehandelings wat ontwerp is om liggaamsmassa by 20 weke tot 15 en 30% benede dié van 'n groep wat *ad libitum* gevoer is te verlaag; twee lae lisienbehandelings, 'n lae proteïenbehandeling wat gebalanseer is met betrekking tot alle aminosure, en 'n kontrole behandeling wat gevoer is volgens huidige kommersiële praktyk. Eierproduksieprestasie is gevolg vanaf 20 tot 68 weke ouderdom. Daar was groot variasie in voerinname tot 20 weke, en henne op die lae lisienbehandeling het die hoogste inname getoon. Liggaamsmassa by 20 weke ouderdom is beduidend verlaag deur alle beperkingsbehandelings en geslagsrypheid is in verhouding vertraag. Die vertraging in geslagsrypheid het 'n beduidende verlaging in die produksie van klein- en gemiddeldegrootte eiers teweeggebring. Teen 68 weke ouderdom was daar geen betekenisvolle verskil in die totale eiergetalle of persentasie hen-behuisde produksie nie. Mortaliteit is nie nadelig beïnvloed by enige van die grootmaakbehandelings nie. Daar was min variasie tussen behandelings gedurende die lêperiode. Nietemin wil dit voorkom asof die kwantitatiewe beperkingsbehandeling die metode van voorkeur is as gevolg van die aansienlike besparing in voerkoste gedurende die grootmaakperiode.

SUMMARY

A total of 2 400 medium type pullets was used in an experiment to compare three methods of nutrient restriction from 2 to 20 weeks of age. The treatments consisted of the following: two quantitative food restriction treatments designed to reduce body mass at 20 weeks by 15 and 30% below that of a group fed *ad libitum;* 2 low lysine treatments; a low protein treatment balanced in respect of all amino acids, and a control treatment reared according to present commercial practice. Egg production performance was monitored from 20 to 68 weeks of age. There was considerable variation in food consumption to 20 weeks, with pullets on the low lysine treatments recording the highest intakes. Body mass at 20 weeks of age was significantly reduced by all restriction treatments, and sexual maturity was delayed proportionately. The delay in sexual maturity resulted in a significant reduction in the production of small and medium sized eggs. At 68 weeks of age there was no significant difference in total mass of eggs produced, total hen-housed egg number, or percentage hen-housed production. Mortality was not adversely affected by any of the rearing treatments. There was very little variation between treatments during the laying period. However, it would appear that the quantitative restriction treatment is the method of choice, due to the considerable saving in food cost during the rearing period.

The restriction of body mass among pullets can be achieved by controlling the nutrient intake during the rearing period. Food restriction can be implemented either quantitatively (limiting access time or the quantity of food supplied), or qualitatively (by feeding low energy or low protein diets, or diets deficient in one amino acid).

The preferred method is that of quantitative nutrient restriction, which has given the most consistent results with regard to biological and economic responses to egg production. There are, however, two serious disadvantages associated with this type of restriction programme. First, the method is time-consuming, as the amount of food allocated must be measured, and second it is difficult to make accurate adjustments consequent to sudden temperature fluctuations or during periods of stress. The ideal method of nutrient restriction, therefore, would be a fully-fed diet which would achieve similar growth limitation as does a quantitative restriction programme.

Two types of diets which have yielded encouraging results when fed *ad lib* to pullets are low lysine and low protein diets (Petersen, Sauter & Lampman, 1966; Lillie & Denton, 1966; Lee, Gulliver & Morris, 1971; Gous, 1975).

The object of this experiment was to compare a low lysine diet and a low protein diet balanced in respect of all essential amino acids with a conventional diet fed *ad lib.*, and a quantitative food restriction treatment with two levels of restriction.

Materials and Methods

Rearing period to 20 weeks of age

2 400 day-old medium type laying pullets were reared in an environmental control rearing house. Each pen measured 4,26 X 4,57 metres and housed 133 pullets. The six treatments (Table 1) with three replicates per treatment, were randomly allocated to the 18 pens. The calculated analysis of the rearing diets

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Table 1

Treatments and rearing diets

Treatment		Period fed (Weeks)	Diet fed (See Table 2)
1	Control	0– 6	1
		7–12	2
		13–20	3
2	Low Protein	0– 2	1
		3– 4	2
		5– 8	3
		9–20	4
3	Low lysine	0– 6	5
		7–12	6
		13–20	3
4	Low lysine	0– 6	6
		7–12	7
		13–20	3
5	15% Body Mass Restriction		
		0– 6	1
		7–20	8
6	30% Body mass Restriction		
		0– 6	1
		7–20	

is presented in Table 2. The chickens were brooded at a temperature of 30°C, the temperature being reduced by 3°C per week until the fourth week after which no artificial heat was supplied. All chickens were debeaked at 7 d of age.

The pullets were reared on a decreasing light pattern, the initial daylength being 20 hours and 40 minutes. The photoperiod was reduced by 20 minutes per week, until a terminal day-length of 14 hours at 20 weeks of age was achieved.

The control treatment was a conventional pullet rearing programme with 3 diets fed *ad lib.* (see Table 1). The objective of the quantitative food restriction programmes (Treatments 5, 6) was to produce pullets with a body mass at 20 weeks of age approximately 15 and 30% below that of the fully-fed control pullets. The body mass of a random 20% of the pullets in each group was determined weekly, and the amount of food allocated to the 2 restricted groups was allocated accordingly. A two-day quantity of food was supplied on alternate days in an attempt to minimise competition, thereby reducing variability in growth rate between pullets.

The low-protein and low-lysine treatments were based on the experiments reported by Lee *et al.* (1971). The low protein treatment was designed to study the effect of reduced protein intake on growth, the reduced protein intake being achieved by feeding the standard chicken rearing diets for periods of short duration to 8 weeks of age, followed by Diet 4 (12% protein) to 20 weeks of age. The 2 low-lysine treatments were designed to study the effect of low lysine consumption

Table 2

Composition (g/kg) of rearing diets

	1	2	3	4	5	6	7	8
Maize	500	532	546	570	537	561	597	532
Gluten	65	65	65	65	65	65	65	
Wheat bran	290	270	240	240	107	196	271	270
Groundnut meal	16	7	—	—	80	91	21	7
Sunflower meal	–	–	–	–	181	56	–	–
Fish meal	118	78	50	21	–	–	5	78
Monocalcium phosphate	2	6	10	13	14	14	14	6
Limestone powder	7,4	8,5	9,5	11,5	10,5	11,5	11,5	7,4
Salt	–	2	3	3	4	4	4	2
Molasses	–	30	75	75	–	–	10	30
Vitamin premix *	0,5(A)	0,5(B)	0,5(B)	0,5(B)	0,5(B)	0,5(B)	0,5(B)	1,0(A)
Mineral premix**	0,5	0,5	0,5	0,5	0,5	0,5	0,5	1,0
Coccidiostat	0,6	0,5	0,5	0,5	0,5	0,5	0,5	0,6
Calculated analysis								
Protein (%)	19,00	16,00	13,70	12,00	19,00	16,00	12,50	16,00
Methionine (%)	0,44	0,36	0,31	0,26	0,38	0,30	0,25	0,36
TSAA (%)	0,79	0,68	0,59	0,53	0,76	0,63	0,54	0,68
Lysine (%)	0,95	0,72	0,55	0,47	0,60	0,48	0,37	0,72
Tryptophan (%)	0,21	0,18	0,15	0,13	0,21	0,17	0,14	0,18
Arginine (%)	1,00	0,80	0,65	0,55	1,34	1,04	0,62	0,80
Calcium (%)	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80
Phosphorus(AV) (%)	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45
ME MJ/kg	10,29	10,29	10,29	10,29	10,29	10,29	10,29	10,29

* Provides per kg of diet: Vitamin premix A: 7024 I.U. Vit. A, 2198 mg pyridoxine, 8,5 mg α tocopherol, 2,0 menapthone, 1,0 mg thiamin, 4,0 mg riboflavin, 7,9 mg calcium pantothenate, 24,7 mg nicotinic acid, 0,3 mg folic acid.
Vitamin Premix B: 7028 I.U. Vit. A, 2180 mg pyridoxine, 1,0 mg menapthone, 1,0 mg thiamin, 3,0 mg riboflavin, 7,9 mg calcium pantothenate, 19,9 mg nicotinic acid.

** Mineral Premix: 4 mg $CuSo_4$, 40 mg ZnO_2, 4 mg I, 80 mg MnO_2.

during the first 12 weeks of life, followed by a slightly higher level of lysine to 20 weeks of age. These low lysine treatments differ from conventional low lysine treatments in which the lysine levels are progressively reduced or remain constant as the pullets age.

Laying period, 20 to 68 weeks of age

At 20 weeks of age, 252 pullets per treatment were placed in the laying house, in 4 replicates of 63 pullets. All birds were fed a commercial mash laying diet *ad lib.* from the age of 20 weeks onwards. Food consumption and food conversion ratio were determined weekly. The daily production records included an egg count, the mass of eggs produced, and a record of the number of eggs in each of four classes graded according to egg mass.

Sexual maturity was regarded as the age at which 10% production was reached. Mortality was recorded throughout the laying period. The experiment was terminated when the birds reached 68 weeks of age.

Results

Rearing period to 20 weeks

The effects of rearing treatments on food consumption and body mass at 20 weeks and at 10% production are presented in Tables 3 and 4 respectively.

On the low-protein regime overall food consumption was not affected, yet body mass was reduced by approximately 9,0% below that of the control at 20 weeks of age. This is in agreement with results obtained in a previous experiment (Maclachlan, Saunders & Gous, 1977).

The feeding of low lysine diets (Treatments 3 and 4) caused a significant increase in food consumption during the period 0 to 6 weeks of age, indicating a marginal and not a severe deficiency of lysine in these diets. During the period 7 to 12 weeks of age a level of 0,48% lysine in comparison to the control of 0,72% resulted in an increased food consumption. However, when the level of lysine was reduced to 0,37% the food consumption was similar to that of the control treatment. This is in agreement with the findings of Lee *et al.* (1971). During the period 13 to 20 weeks of age the pullets previously fed the 2 low lysine diets were fed standard developer feed as suggested by Lee *et al.* (1971), and food consumption was similar to that of the control treatment.

The overall conclusion from the results to 20 weeks of age is that slightly reduced levels of lysine increase food consumption, and that this effect is reversed at lower levels of lysine. The low lysine diets did, however, reduce the body mass of the pullets significantly by 20 weeks of age. The lowest lysine level caused the largest body mass reduction.

As would be expected, pullets on Treatments 5 and 6 had a significantly lower food consumption than the controls because of the quantitative nature of the restriction treatments.

Quantitative food restriction caused a reduction in body mass, as was planned. The results of Treatments 5 and 6 indicate that when food was restricted by 15 and 30%, body mass was reduced by 17 and 30% respectively.

The effect of rearing treatment on body mass at 10% production is less pronounced than the effect at

Table 3

Food consumption during various stages of growth

Period Age in weeks	Treatment							
	1	2	3	4	5	6	SEM	CV (%)
0–5	963^{b}	922^{b}	$1\,228^{a}$	$1\,200^{a}$	907^{b}	986^{b}	± 25,7	4,32
6–12	$2\,917^{b}$	$3\,022^{b}$	$3\,320^{a}$	$2\,950^{b}$	$1\,986^{c}$	$1\,863^{c}$	± 76,5	4,95
13–20	$4\,771^{a}$	$4\,737^{a}$	$4\,681^{a}$	$4\,741^{a}$	$3\,985^{b}$	$3\,200^{c}$	±167,0	6,60
0–20	$8\,651^{bc}$	$8\,681^{abc}$	$9\,229^{a}$	$8\,891^{ab}$	$6\,878^{d}$	$6\,049^{c}$	±192,7	4,10
0–10% Production	10 191	10 607	11 252	11 211	9 130	8 663	±160,8	3,16

a, b, c, etc., = values with same superscript in each row do not differ significantly ($P < 0.05$)

SEM =Standard Error of treatment mean

CV =Coefficient of variation (per cent)

Table 4

Effect of rearing treatment on body mass

Variate	Treatment 1	2	3	4	5	6	SEM	CV (%)
Body mass at 20 weeks	1 671^{a}	1 523^{b}	1 494^{c}	1 389^{d}	1 383^{d}	1 184^{e}	16,3	1,96
Body mass at 10% production	1 797^{ab}	1 809^{a}	1 791^{abc}	1 763^{bcd}	1 731^{cd}	1 700^{d}	21,2	2,41

a, b, c – see footnote to Table 3

Table 5

Effect of rearing treatment on 20 week parameters

Treatment	Food cost 0–20W (cents)	Food cost day old to sexual maturity (cents)	Food conversion ratio 0–20W	Age at sexual maturity (days)	Mortality (%)
1	56,0^{a}	68,0^{c}	5,3^{bc}	155,7^{a}	3,76
2	52,7^{b}	67,7^{c}	5,7^{b}	159,8^{b}	3,40
3	58,4^{a}	74,2^{a}	6,2^{a}	160,5^{b}	3,94
4	53,1^{b}	71,4^{b}	6,4^{a}	163,0^{c}	4,12
5	47,5^{c}	64,9^{d}	5,0^{d}	162,8^{c}	3,01
6	41,9^{d}	62,3^{e}	5,1^{cd}	166,3^{d}	3,94
SEM	0,66	0,80	0,14	0,68	1,57
CV (%)	2,20	2,35	4,20	0,84	3,71

a, b, c – see footnote at end of Table 3

20 weeks of age. Although the most severely restricted groups were significantly lighter than controls, on reaching sexual maturity the differences were greatly reduced (Table 4). The greater discrepancy in body mass at sexual maturity between birds on different treatments in this experiment than in the previous experiment (Maclachlan *et al.*, 1977) is in close agreement with the work of Gous (1975).

The effect of rearing on feed costs, feed conversion, sexual maturity and mortality is presented in Table 5. Feeding cost per pullet was reduced by 3 cents in the case of Treatments 2 and 4. Treatment 3 increased feed costs by 2 cents per pullet compared with the control. The 17% quantitative food restriction treatment reduced feed costs to 20 weeks by 8 cents per pullet, and the 30% restriction treatment reduced feed cost by 12 cents per pullet.

As in the case of body mass, differences in feed costs to 10% production were less pronounced. In this case low protein feeding cost the same as did the control, low lysine increased feeding costs and quantitative restriction reduced feeding costs. Nutrient restriction treatments reduce body mass and delay sexual maturity, since the attainment of sexual maturity is related to the degree of restriction. Although the low lysine diets caused the highest feed intake at 20 weeks of age, body mass of pullets on these diets was reduced, and sexual maturity was delayed. Consequently these two treatments (Treatment 3 and 4) had the highest feed costs to 10% production. The quantitative restriction treatments produced the largest reduction in body mass and delay in sexual maturity, yet their total feed costs were the lowest, because the additional feed consumed to 10% production was more than offset by the saving in food during the rearing period to 20 weeks of age.

Mortality was not adversely affected by any of the rearing treatments.

Laying Performance

The results of the laying period are presented in Tables 6 and 7 respectively. The effect of nutrient restriction on age at sexual maturity is shown in Table 5, the delay of 4, 5, 5, 7 and 13 days for Treatments 2 to 6 being proportional to the reduction in body mass at 20 weeks of age.

There was little variation in total production between treatments for the entire laying period. The production by pullets that had been subjected to restricted treatments during rearing was slightly lower than that of the control, in both hen-housed egg number and total hen-housed egg mass. Conversely, the percentage hen-day production favoured the restriction treatments. The variation in food conversion and food intake was relatively small, but it is noteworthy that the large appetite of the low lysine treatments was maintained throughout the laying period and is responsible for the high food conversion ratio of these 2 treatments.

The delay in sexual maturity brought about by nutrient restriction caused a significant reduction in the production of small and medium sized eggs, the reduction in general being proportional to the delay in maturity.

Table 6

Food intake, food conversion ratio and egg production to 68 weeks of age

Treatment number	Total production hen-housed/bird	Total production hen-day/bird	Total egg mass hen-housed/bird	Food conversion ratio	Food intake/bird day
1	218,45^{a}	67,58^{a}	12,456^{a}	2,793^{a}	107,61^{a}
2	212,68^{a}	67,70^{a}	12,119^{a}	2,848^{a}	109,83^{a}
3	211,83^{a}	66,50^{a}	12,132^{a}	2,845^{a}	108,25^{a}
4	211,58^{a}	68,23^{a}	11,815^{a}	2,905^{a}	110,60^{a}
5	213,68^{a}	68,93^{a}	12,219^{a}	2,790^{a}	109,86^{a}
6	216,18^{a}	68,53^{a}	12,269^{a}	2,770^{a}	107,66^{a}
CV (%)	3,01	2,28	2,89	2,43	1,51
SEM	1,267	0,311	0,075	0,014	0,391

a; CV; SEM – see footnote to Table 3.

Table 7

Grouping of eggs according to mass as a percentage of the total laid, and production per pullet of small eggs to 28 weeks of age

Treatment number	Extra large > 61 g	Large 51–60 g	Medium 41–50 g	Small < 41 g	Small 20–28 weeks
1	20,60^{a}	67,56^{a}	11,63^{b}	0,21^{a}	1,167^{a}
2	21,23^{a}	66,16^{a}	12,47^{b}	0,14^{b}	0,018^{a}
3	22,03^{a}	66,71^{a}	11,13^{c}	0,13^{b}	0,935^{a}
4	16,91^{a}	69,39^{a}	13,64^{a}	0,06^{c}	0,488^{b}
5	20,67^{a}	68,88^{a}	10,37^{c}	0,08^{c}	0,408^{b}
6	19,06^{a}	68,36^{a}	12,51^{b}	0,07^{c}	0,418^{b}
CV (%)	13,89	3,17	12,25	25,69	33,84
SEM	0,580	0,446	0,365	0,014	0,108

a, b, c; CV; SEM – see footnote to Table 3.

Discussion

The results of the low protein rearing treatment show that such levels of protein are adequate for normal growth and support the view of Lee *et al.* (1971) that the feeding of high levels of protein for relatively long periods during rearing is unnecessary and wasteful. It should be borne in mind that the amino acid content of these low protein diets must be balanced in respect of all essential amino acids.

The two low lysine treatments had a considerable effect on growth to point of lay. If the lysine level of the diet is low enough to cause a marginal deficiency the pullet will overeat in an attempt to compensate for the inadequate lysine concentration. Once the lysine level is low enough to cause a severe deficiency then food intake is depressed and growth is retarded. These effects were experienced in Treatments 3 and 4 during the period 6–12 weeks of age. During this period pullets on treatment 3 received Diet 6 (0,48% lysine) which created a marginal lysine deficiency, thereby causing an increase in food consumption, whereas pullets on Treatments 4 received Diet 7 (0,37% lysine) which depressed food intake.

Reduction in body mass is normally proportional to the severity and duration of the nutrient restriction, (Lee *et al.* 1971; Gous, 1975) and in this experiment Treatments 5 and 6 recorded the lowest body mass because of the quantitative nature of the restrictions. Part of this body mass loss must be made up before production commences, hence the delay in sexual maturity in restricted pullets.

The food restriction programmes are advantageous to the pullet rearer, because of the saving in food costs. Food costs to 20 weeks of age for the 6 treatments were 56,0c; 52,7c; 58,4c; 53,1c; 47,5c and 41,9c respectively. Food costs to 10% production were 68,0c; 67,7c; 74,2c; 71,4c; 64,9c and 62,3c respectively.

There was little variation in daily food intake and food conversion during the laying period. The slight increase in food consumption and poorer food conversion evident in all five restriction treatments proved to be non-significant. The marginal increase in food intake of pullets on the restriction treatments during lay can be attributed to the compensatory effect of *ad lib.* feeding following food restriction during rearing.

Restricted-reared pullets usually reach a higher peak of egg production than those fully-fed during the rearing period. For equal periods after maturity, a higher average rate of lay can be expected. For egg production to a fixed finishing age there is no difference on average between fully-fed and restricted flocks (Lee *et al.*, 1971). These observations are substantiated by the results obtained in this experiment: there was no significant difference in total hen-housed egg mass, hen-housed egg number or percentage hen-housed production.

Although pullets subjected to the restriction treatments produced slightly fewer eggs, total egg mass production was similar due to the larger initial egg mass of the restricted treatments.

The results of this experiment support the view that egg size is a function of the chronological age of the bird rather than of the state of its physiological development or rate of lay. The differences in average egg size and grading are due to differences in the number of small eggs produced. Food restriction during rearing retards growth and delays sexual maturity, thus when egg production commences, egg mass is greater.

The use of low protein diets and lysine deficient diets during the rearing period offers an effective means of delaying sexual maturity of pullets. However, it is not clear from this experiment, or from published evidence whether a diet deficient in lysine, in any other amino acid or in total protein content is to be preferred. Whilst considerable evidence exists concerning the effects on biological performance of quantitative food restriction there is little information relating to protein restriction.

Useful information would be obtained from experiments comparing varying degrees of energy and protein restriction during the rearing period and from observations on the effect of these rearing treatments on subsequent biological performance. Lee *et al.* (1971) maintain that in most experiments using protein restriction there was primarily a restriction of lysine intake. It seems important to establish whether different biological responses would result from the limitation of amino acids other than lysine.

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