THE EFFECT OF FEED RESTRICTION OF EGG TYPE PULLET DEVELOPMENT AND SUBSEQUENT EGG PRODUCTION

BY

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This thesis, "The effect of feed restriction on egg type pullet development and subsequent egg production" by Adetoun Adetokunbo Seloni meets the regulations governing the award of the degree, Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my parents Adebowale and Felicia Omoteso.

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ABSTRACT

The effect of qualitative and quantitative feed restriction during rearing on subsequent egg production was investigated.

For the qualitative feed restriction studies, isocaloric experimental diets containing different combinations of 20, 16 and 12% crude protein (C.P.)diets were fed in two experiments (1 and 2) from day old to 20 weeks of age. A common layer ration of 16% CP and 2,400 Kcal ME/kg diet was fed from 20 weeks. Each experiment lasted 36 weeks. In the two experiments, a protein level of 12% was found to be inadequate for the proper growth of the birds between 0-8 weeks. However, 12% CP was found to be adequate from 9-20 weeks. Also 16% CP diet was found adequate for birds from 0-20 weeks. In experiment 2, birds fed 12% protein from 0-8 weeks compensated in performance when the level of dietary protein was increased between 9-20 weeks. The protein regimens fed between 0-20 weeks did not significantly affect egg production nor the ages of the birds at sexual maturity and peak production. Also hen-day and hen-housed egg productions as well as cost of feed per unit weight or dozen eggs were not significantly affected by the dietary protein regimen fed pre-lay.

For quantitative feed restriction studies (experiments 3 and 4), all the birds were fed ad-libitum on 20% CP diet (2649 Kcal ME/kg) from 0-8 weeks. From 9-20 weeks feed was denied to the birds for a day after one or two days of ad lib. feeding or restricted to 75% of ad lib. intake by the control birds. Results of these two studies showed that with restriction a significant decrease in growth rate was obtained at 20 weeks and at the end of the experiments. However, the feed regimens imposed on the birds during the growing period did

not have any significant effect on sexual maturity nor peak production levels. Hen-day and hen-housed egg production levels as well as cost of feed per unit weight or dozen eggs were not significantly affected by the treatments.

These studies show that when fed diets low in protein, growing birds have the capacity for compensatory gains when level of protein is improved. Also when growing birds are restricted in quantity of feed fed they respond with a reduction in mature weight. In either case of restriction on the production in the laying period is unaffected.

INTRODUCTION

Feed represents 60-65 percent (%) of the cost of producing a dozen eggs (Summers, 1975). The ever increasing cost of feed coupled with the scarcity of most of the feed ingredients make research into feed restriction of both pullets and laying hens a necessity in this country. There is the need to investigate possible ways of cutting down on the cost of production of the egg to suit both the producer and the consumer. One of the ways of cutting down on the cost of production is to reduce the cost of raising the pullets from hatch to point of lay. Feed restriction is a method that can be utilised to achieve this desired reduction in cost. Apart from reduction in the cost of raising replacement pullets, feed restriction has also been used to delay maturity of pullets in order to reduce the number of small eggs laid initially by pullets.

The effect of intermittent fasting of the fowl was studied as early as 1887 (Von Seeland, quoted by Gowe et al., 1960) but there was little interest in the effects of feed restriction in poultry until Dr. O.A. Ken of the Quaker Oat Company recommended this procedure about 1937 (Bruins, 1958 quoted by Gowe et al., 1960). It was about 15 years later that a controlled experiment on this subject was undertaken, and since then several studies have been undertaken involving the use of feed restriction in the control of sexual maturity in pullets (Nesheim et al., 1979). Feed restriction has not been limited to laying chickens alone, but has been extended to other species such as turkey (Meyer et al., 1977; Moran et al., 1983) and ducks (Plavnik et al., 1982).

iv. The use of protein defficient diet during the growing period from hatch offers a good way of delaying sexual maturity but special ration formulations are required.

Although much work has been done on the subject, there is limited report on feed restriction in the tropics. Conscious too of the high cost and problems of availability of feed in Nigeria, this study was designed to investigate whether feed restriction can have a practical application in Nigeria in particular and in the tropics in general.

For this work two methods of feed restriction were used, namely:

i. quantitative feed restriction and

ii. qualitative feed restriction with low protein diets, because of their afore-mentioned merits.

Under the quantitative feed restriction, three treatments were used from 9-20 weeks, namely:

i. Skip a day feeding

ii. Skip a day after every 2 days of feeding

iii. restriction of feed to 75% of the previous week's feed intake of the control birds.

Qualitative feed restriction was divided into:

a. step-down protein regimen

b. single stage protein regimen

c. step-up protein regimen

The criteria measured included mortality; ages at first egg, 5% production, 50% production and peak production; feed intake and feed conversion efficiency; weight of birds at 8 and 20 weeks; and egg production (hen day and hen housed).

REVIEW OF LITERATURE

Importance of Feed Restriction

The increase in the cost of grains which constitute the greater fraction of poultry rations and the ever increasing cost of protein have necessitated the urgent need to rationalize the consumption of both protein and energy by all types of livestock, especially poultry, without compromising production efficiency.

Energy Restriction

In the poultry industry, feed represents 60-65% of the cost of production (Summers, 1975). Poultry for both meat and eggs are usually fed ad libitum throughout both growing and laying periods. This practice is based on the assumption that birds eat only enough to satisfy their energy requirement. It has now been established that the energy requirements of laying hens estimated from calorimetric studies were generally lower than energy intakes observed under field conditions (Balnave et al., 1978). This is because maintenance requirement is influenced by voluntary and involuntary activities of the bird and the environmental temperature. In the calometric studies, Balnave et al. (1978) placed a hen in each of the three respiratory chambers and offered them commercial layer's diet of known crude protein and energy levels. Each experiment was divided into two periods of (a) ad. lib. feeding (b) restricted feeding,this was done in order to determine the energy balance at different levels of intake. The hens were offered feed at a pre-determined level for at least three days, and heat production was measured for three to four consecutive days on fed birds.

Limiting the energy intake of pullets and laying hens under commercial conditions have yielded extremely variable results.

In a review Sykes (1972), suggested that hens fed ad libitum consume as much as 30 or 40% more energy than was required and that the excess energy is deposited as fat. Auckland and Fulton (1973) reported that light and medium hybrids of laying hens were allowed to consume from 24 to 52 weeks of age, ad libitum or approximately 1200, 1154, 1107 and 1062 kilo Joule (KJ) Metabolizable energy per bird per day (KJME/bird/day). A sixth treatment consisted of the lowest level of energy but higher levels of protein, calcium and phosphorus. From 52 to 58 weeks, all birds were fed ad libitum and treatments were re-imposed from 58 to 68 weeks of age . In the 24 to 68-week period,rate of lay decreased progressively with decreasing energy intake. The rate of lay of medium and light hybrids allowed 1200 KJME/day was respectively, about 10 and 4 percentage points lower than controls. Initially, differences in rate of lay in relation to energy intake were small, but became more marked as restriction continued. During the 6-week rehabilitation period, previously restricted groups tended to lay more eggs than control birds. With both strains of birds the rate of lay tended to decrease as energy intake was reduced. Restricted groups lost between 6 and 12% of the their body weight in the first 16 weeks but regained a little in the succeeding 12 weeks.

The findings above agreed with the report by Auckland and Wilson (1975a) in which two light and two medium hybrid strains were fed from 32 to 48 and from 56 to 68 weeks of age, ad libitum or approximately 89%, 85% and 80% of the ad libitum intake. From 48 to 56 weeks all the birds were fed ad libitum. The study used less severe levels of energy restriction when compared with that of Auckland and Fulton (1973). A daily energy restriction of 11 to 13% from 32 to 48 weeks of age, resulted in rate of lay being depressed

by about 11% for light hybrid strain and by more than 5% for medium hybrids. The corresponding depressions in egg weight were 4% and 2% respectively. Energy restriction of about 8% during the second period (56 to 68 weeks) depressed rate of lay by about 3% and egg weight by about 2%. These results also supported the works of Snetsinger et al. (1974) and Mbugua and Cunningham (1983). These workers showed that egg production can be maintained when energy intake is restricted by not more than 6%; beyond this, a significant depression in rate of egg production would result.

On the other hand, Jackson (1970) showed that restriction of a high energy diet (2800 Kcal/kg) significantly decreased egg production. Like-wise Nair and Ramakvishnan (1978) obtained a 6% decline in egg production when there was a 6% decline in feed consumption, unfortunately these workers did not indicate the energy level used in their experiment. The work of Abu-Serewa (1978) involved feeding a ration of 12 MJME/kg diet and observed that egg production was not affected by feed restriction while Robinson et al. (1978) and Voitle et al. (1974) using 12.33 MJ/kg and 2750 Kcal ME/kg diet respectively reported increased egg production with feed restriction.

From the above diversed views on energy restriction, a lot of factors affect the response of birds to feed restriction which include:

a. Type of breed. Auckland and Fulton (1973) reported that depression in rate of lay due to the same level of restriction was considerably greater with medium than with light hybrids, being about 10 and 4% for medium and light hybrids respectively. Likewise Auckland and Wilson (1975a) using a moderate energy restriction of 11-13% less than ad libitum intake, observed considerable depression in rate of lay, of about 11% for light hybrid and more than 5% for medium hybrids.

b. Type of strain. Mbugua and Cunningham (1983) used two heavy strain of birds A and B and two light strains C and D for their work on feed restriction and reported that amongst the heavy strains, strain B had significantly lower hen-day egg production than strain A and amongst the two light strains, strain C had a significantly higher egg production than strain D. There was also a significant difference in time of reaching sexual maturity between the heavy and the light strains of pullet. The heavy strains reached sexual maturity 8 days earlier than the light strains.

c. Method of restriction. In the report of Connor et al.(1977) restricting birds intake during lay gave additional improvements in feed efficiency over and above those produced by growing period restriction alone. Contrary to the above report, Robinson et al. (1978) observed that birds that were restricted in the rearing period laid 7.3 more eggs on henday basis, suffered 8.3% less mortality and produced 19.3 more eggs per hen-housed than those restricted by no more than 6% in the laying period.

d. Duration and age of birds when restriction starts. In the study by Balnave (1974), restricted feeding during the laying period substantially reduced the feed intake and also had a detrimental effect on rate of egg production and on total weight of eggs produced when compared with those restricted during the growing phase. This is in agreement with the work of Auckland and Wilson (1975b) in which the overall energy intake and consequent egg output tended to be greater for treatments with a total of 24 rather than 28 weeks of restriction. Abu-Serewa (1978) also reported a significant interraction between the

duration of restriction and early feeding regimen in total food consumption from day old to 20 weeks of age. Birds fed ad libitum from 3 weeks to 6, 9 or 12 weeks consumed more feed to 20 weeks than birds fed for five days in each week during the same period. Lee (1983) used 4 methods of feed restriction namely low protein diet, low energy diet, skip feeding two days a week and daily 30% restricted feeding and reported that age to sexual maturity was significantly (P(0.05) delayed by daily 30% restricted feeding only which resulted in the lowest production from 20-28 weeks of age. However during the remainder of the production period the daily 30% restricted feeding birds consistently had higher egg production than birds in any other group.

Protein Restriction

Limiting the amount of protein available to the replacement pullets is another form of feed restriction. Protein levels of 9-12% have been shown to support pullet growth and to improve subsequent egg production as compared to 14 to 15% protein diets (Douglas et al., 1973; Christmas et al., 1974; Carlson and Nelson, 1981). Lee et al. (1971) reported in their review that protein restriction diets offered a more suitable means of retarding sexual maturity for beneficial effects. Low protein grower mash reduced cost of pullet production, delayed sexual maturity, delayed production peak, increased egg size at 50% production and maintained higher levels of production near the end of the laying period (Christmas et al., 1974). Christmas et al. (1974) however observed that low protein diet fed birds were lighter in body weight at the end of the growing period, had increased cannibalism during the growing phase and had lower egg production

and higher mortality in the laying house.

Carlson and Nelson (1981) recommended that diet not higher than 12% protein need be used for growing layer-type pullets after 10 weeks of age under the present day conditions. They also showed that 12% protein layer diets could be economical if the relative cost of the 16% and 12% crude protein diets differ by about 10%. These findings show that considerable saving can be made by restricting protein intake of both replacement pullets and layers.

Qualitative Feed Restriction on Pullets and Layers

The feeding programme of egg strain pullets have traditionally involved the use of high protein starter diet and lower protein grower diets (Scott et al., 1976). The nutritional requirements of the growing pullets are difficult to categorize, since production standards are not well defined unlike in broilers. Performance in the laying house is the usual measure of a good pullet. An evaluation of a rearing programme is commonly based on:

a. 20-week body weight
b. level of sexual maturity
c. conformity of body size and
d. feathering

These were the four measures used in the traditional subdivision of growth into starter (0 to 6 or 8 weeks) and grower/rearer (6 or 9 to 20 weeks) phases. A high protein diet (18-20% crude protein) is used from day old to ensure a good start, this is usually followed by a lower protein (15-16%) grower diet in order to delay sexual maturity and body weight gain.

A lot of work has been done on the use of low protein diet to delay sexual maturity and to reduce 20 week body weight. These can be subdivision into three main programme as follows:

a. Step-down low protein

b. Step-up or reverse protein

c. Single stage low protein programmes

(a) Step-down low protein programme

One of the favoured procedures of feed restriction is the use of reduced dietary protein or amino acid levels (Balnave ,1973). Several studies have been done on the use of low protein diet for growing pullets. A protein level as low as 9-10% has been used successfully (Wright et al., 1969; Douglas et al., 1973; Christmas et al., 1974) to support improved subsequent production as compared to 14 to 15% protein diets.

In the work of Christmas et al. (1974) 12 commercial egg production strains were fed either 9.07 or 15.35% protein from 8 to 18 weeks of age and 15.35% protein thereafter. These authors found that the low-protein grower diet reduced the cost of pullet production, delayed sexual maturity, delayed production peaks, increased egg size at 50% production and maintained higher levels of production near the end of the laying period. Christmas et al. (1974) therefore indicated that low protein diets can be fed to birds that will come to lay when egg market prices are low and egg size is at an advantage.

On the other hand, Douglas and Harms (1976) grew commercial Leghorn-type pullets to eight weeks of age on a diet containing 21% protein. At 8 weeks some of the pullets received 9% protein to 18 weeks and 14% protein from 18-20 weeks. The other groups (2 and 3) received 14% and 21% protein grower diets respectively. From 20 through 60 weeks of age all birds were maintained in laying cages

and fed a layer diet of 16% protein. At 20 weeks of age average body weight of pullets fed 9%, 14% and 16% protein grower diets were 1175, 1356 and 1433 grams respectively and at 60 weeks of age body weights were 1637, 1647 and 1710 grams respectively. Hens that received 21% protein through out laid eggs that were approximately one gram heavier than eggs laid by hens from the other two groups. The authors concluded that a higher protein diet during growing period resulted in larger egg size when hens reach peak production during periods of high temperature.

In the review of Lee et al. (1971), protein restriction diet was reported to offer suitable means of retarding sexual maturity for beneficial effects when compared to the other types of restriction. Blair et al.(1970) also reported 11.5% crude protein (2955 Kcal ME/kg) grower diet to be adequate for subsequent egg production, feed conversion and mortality. Carlson and Nelson (1981) recommended that a diet not higher than 12% protein (2970 kcal ME/kg) need be used for growing layer-type pullets after 10 weeks of age. They found no interraction between grower diet and layer diet which indicates that pullets grown on low protein diets did not require more protein during the laying period to compensate for possible reduced protein stores.

(b) Step-up or reversed protein programme

Growth rate of pullets is divided into starter (0 to 6 or 8 weeks) and grower/rearer (6 or 8 to 20 weeks) phases. A high protein diet is used as starter (Scott et al., 1976; NRC, 1984) followed by lower protein grower diet in order to delay sexual maturity and body weight gain. This classification resulted in the common situation of studying these phases in isolation (Blair et al.,

1970; Balnave, 1976; Carlson and Nelson, 1981) instead of studying the growth from hatch to 20 weeks of age.

A complete reversal of the protein intake of growing pullets came to light in the work of Summers and Leeson (1978). In this study, calculations showed a consumed dietary equivalent of 11.4, 11.3, 17.9 and 19.3% crude protein during the 4 to 8, 8 to 11, 11 to 14, 14 to 17 and 17 to 20 weeks growth periods respectively. This led the workers to postulate that the pattern of protein "requirement" was related firstly to a relatively slow initial growth rate (compared with broiler strains that require a quicker initial growth rate and secondly to the development of reproductive organs around 12 to 14 weeks of age. This led to the pioneering work on step-up or reversed protein programme by both workers (Leeson and Summers, 1979).

Leeson and Summers (1979) fed diets containing 12, 16 and 19% crude protein from 0-8, 8-12 and 12-19 weeks respectively. Results of this experiment showed significantly smaller birds at 20 weeks. This reduction in body weight of bird on step-up protein showed a reduced feed and energy intake. With the weight at point of lay controlled, the initial rate of egg production showed that these birds were physically more matured than control birds. These results were further confirmed by them and other workers (Leeson and Summers, 1980, 1982; Doran et al., 1983; Bish et al., 1984; Robinson et al., 1986). On the other hand, Maurice et al. (1982) fed brown egg strains chickens step-up protein diets but did not observe a significant reduction in weight gain. Using a logistic curve, Maurice et al. (1982) reported a delayed maximum rate of growth.

Leeson and Summers (1980) have related body weight reduction to reduced absolute and proportional fat depots and decreased carcass protein.

Pullets fed step-up protein diets consume significantly less feed to 16 weeks (Leeson and Summers, 1979), less feed to 20 weeks (Leeson and Summers,1982; Bish et al., 1984; Robinson et al., 1986) and less total protein (Leeson and Summers, 1979, 1982) than pullets reared on convectional step-down protein programmes. These findings suggest a potential economic savings for step-up protein programme.

Hen-day egg production was not significantly affected by step-up protein feeding (Leeson and Summers, 1979, 1982; Maurice et al., 1982; Doran et al., 1984; Robinson et al., 1986). Decreased egg weight was reported by Leeson and Summers (1979), Maurice et al. (1982) and Doran et al. (1983) while Leeson and Summers (1982), Bish et al. (1984) and Robinson et al. (1986) reported no significant difference in egg weight. Step-up protein programme was further modified by Bish et al. (1984) and Robinson et al. (1986). Both groups of workers fed a high protein diet (16 to 20% crude protein) for the first week of life followed by a 12% crude protein diet to 8, 10 or 12 weeks 15-16% thereafter to 16 weeks and 18-19% to 20 weeks of age. This resulted in smaller birds at 20 weeks and a reduction in total feed intake when compared to conventionally fed birds. No advantage was reported when modified step-up protein programme was used. The crude protein level of diet fed during the first week did not significantly influence total protein consumption (Bish et al., 1984; Robinson et al., 1986).

(c) Single stage low protein programme

Leeson and Summers (1982) did another pioneering work on the use of single stage low protein programme to raise pullets from day old to 19 weeks. The single stage low-protein diet resulted in reduction in body weight to 16 weeks to 16 weeks of age relative to control birds fed convectional step-down protein programme. Protein

intake was significantly less but performance including egg size was not adversely affected. This suggests that conventionally fed birds consume excessive quantities of protein during the rearing period. Leeson and Summers (1982) also reported that energy level had little effect on the pullets response to single-stage low protein diets. The growing pullets seem adept at controlling their energy intake (Leeson and Summers, 1981). Maurice et al. (1982) further confirmed the need to use low protein starter diets for replacement pullets. In their work 13% crude protein diet with the amino acid adjusted gave comparable results in terms of age at 50% production or peak production, feed conversion and feed intake. The single stage low protein method of feeding also had a practical advantage since it is very simple to operate.

Quantitative Feed Restriction

Quantitative feed restriction involves the allocation to birds a predetermined percentage of the feed consumed by the fully fed controls. This is either done on daily basis or giving feed ad libitum on some days and giving no feed at all on other days.

Duration of the restricted feeding

Pullets have been restricted in feed consumption from as early as 3 days of age (Mbugua and Cunningham, 1983). Ringrose (1956), Strain et al. (1965), MacIntyre and Gardines 1964 (all cited by Lee et al., 1971) started feed restriction at varied ages between 2-5 weeks of age. The more usual restriction period adopted commences between 6 and 8 weeks and terminates between 18 and 24 weeks of age (Hakim and Attia, 1975; Gous, 1977; Tsvetnov et al., 1978; Wilson et al., 1983; Lee, 1983).

The earlier the feed restriction is introduced the greater is the reduction in body weight and the delay in maturity.

Feed restriction in laying hens may start as early as 21 weeks. (Douglas et al., 1977), 24, 28 or 36 weeks (Auckland and Fulton, 1973; Cunningham and Polte, 1984; Cunningham, 1984) to last few weeks or may extend throughout the laying period.

Effect of Quantitative Feed Restriction

I. Pullets

a. Body weight of pullets

One of the objectives of feed restriction is to reduce the body weight of the pullet at maturity. A lighter matured body weight means less feed will be required for body maintenance therefore improving the efficiency of conversion of feed to egg. Cumming (1972) suggested that in any feed restriction programme the objective should be to produce pullets of 25% less weight than full fed birds at point of sexual maturity. He also found that the laying performance of the restricted birds varied with their body weight at the end of the restriction period. In contrast, Watson (1974) reported that the exact level of rearing restriction was unimportant over a wide range in bringing about a production response. In this report birds were restricted to 80, 70 and 60% ad lib. feed intake to produce birds respectively weighing 85, 77 and 68% of full fed body weight at 22 weeks. At point of lay the birds were weighing 93, 93 and 91% of the full fed body weight.

Following the several studies on feed restriction there is a general agreement among researchers that feed restriction reduces the body weight of birds and the level of restriction determines the level of reduction in the matured body weight (Bullock et al., 1963;

Cumming, 1972; Watson, 1974; Hakim and Attia, 1975; Mbugua and Cunningham 1983; Soller et al., 1984). If restriction is stopped earlier than 17 to 18 weeks of age the bird is able to compensate and the effect of restriction on maturity is nullified (Fuller and Dunahoo, 1962; MacIntyre and Gardiner, 1962 cited by Lee et al., 1971). On the other hand, MacIntyre and Gardiner,(1962 cited by Lee et al., 1971) also reported that extending the restriction to 27 or 29 weeks of age reduced egg production.

(b) Sexual maturity

Age at first egg and age at a specified level of production e.g. 5, 10 or 50% are adopted measures of sexual maturity. The age of the flock when the first egg is laid as opposed to mean age at first egg (i.e. the mean ages of several birds at first egg), tends to be a measure of maturity of a minority of a population of pullets and it is subjected to a high sampling error. Mean age at first egg is a better measure of sexual maturity as the number of sample is more than one thereby reducing the sampling error. A measure of mean age at sexual maturity such as age at 50% lay is more appropriate. In the review of Lee et al. (1971) there is a significant association between body weight at the end of the rearing period and delay in sexual maturity.

The data of Ashcroft (1961) (cited by Bullock et al., 1963) showed an increase in age to sexual maturity of 0.6 day for every 1% decrease in feeding level from 90 to 70% restriction. There also exist a relationship between levels of feed restriction and the subsequent delay in maturity. Bullock et al. (1963) reported that energy restriction alone delayed age at 50% lay by 7 days relative to the control diet.

diets
The control and energy restricted / , contain 1175 and 822 kcal ME/ lb. respectively with 15% crude protein.

Abu-Serewa (1978) reported a delay of 15 days to reach 50% production when birds were fed 5 days in the week. Mbugua and Cunningham (1983) using heavy strain birds reported a delay of six days when birds were allowed access to feed on alternate days and were allowed 95% that consumed by the control group the previous week. The extent of delay in sexual maturity depends on the types of birds and on the severity of restriction (Abu-Serewa, 1978; Mbugua and Cunningham, 1983).

Feed Restriction and Subsequent Egg Production

In the work of Bullock et al. (1963) egg production of previously restricted pullets was maintained at a high level and there were no significant differences in total yield associated with treatment. Restricted birds reached a later and slightly higher peak and showed a slower decline thereafter.

Abu-Serewa (1978), reported no significant differences or interactions between factorial restriction treatments in rate of lay, hen housed production, average egg weight, egg quality characteristics, egg grades, final body weight and rate of mortality. He however found restricted bird less efficient in the conversion of feed to eggs, 3.12 versus 2.92 kg/doz eggs for restricted and control birds respectively. The above report was also in agreement with Mbugua and Cunningham (1983) who reported that egg production was not effected by feed restriction statistically although there was a tendency towards decreased egg production with increased feed restriction.

On the other hand, Nair and Ramakrishnan (1978), and Gous (1978), reported drops of 6 or 10% in egg production when replacement pullets were fed for 6 days out of 7 or when feed allowance was set to 70% of that allowed the control. These varied reports may be due to the different methods used and the types of birds involved.

II. Layers

Quantitative feed restriction has been in practice for a long time. The effect of dietary energy restriction in laying birds has been reviewed by Sykes (1972). He indicated that hens fed ad-libitum consumed as much as 30 to 40% more energy than is required and the excess energy is deposited as fat. He suggested the need to limit the intake of laying birds so that the excesses are eliminated. A lot of research work has been done on ways of eliminating these excesses and have resulted in conflicting reports. Temperton and Dudley (1948) (cited by Sykes, 1972) showed that feed restriction up to 90% of the voluntary intake could be imposed without any loss of production. Other reports on egg laying strains indicate that production invariably suffers when feed restriction were imposed (Sherwood and Milby, 1961; Walter and Aitken, 1961; McGinnis and Doronowat, 1967; Jackson, 1970; Auckland and Fulton, 1973; Chaney and Fuller, 1975; Blair et al., 1976; Pearson and Herron, 1980).

These results in addition to the increasing use of bulk feeding systems led to the practice of feeding to appetite. In restricting the feed intake of laying hens, attempts should be made to maintain an adequate daily consumption of all nutrients other than energy in order to maintain if not improve egg production (Auckland and Fulton, 1973). Jackson et al. (1969) reported that the efficiency of Metabolizable Energy (ME) utilization decreased with increasing dietary ME content.

This they thought leads to excessive deposition of fat in the hen. They concluded that restriction must be applied when feeding diets of high energy concentration.

In the report of Heywang (1940), laying hens were restricted to 75 and 87.8% of the amount consumed by control groups fed ad libitum and found that restriction decreased egg production but did not affect size of the eggs or the average body weight of the hens. Decrease in egg production as a result of mechanically restricting the feed intake was also reported (Sherwood and Milby, 1961; Walter and Aitken, 1961). Improved feed utilization was also observed by these workers. Jackson (1970) Polin and Wolford (1971) as well as Bell and Moreng (1972) also observed decreased egg production and reduced egg weight with improved feed utilization as a result of mechanical feed restriction.

Some other workers have reported improved egg production with restriction. In the report of Snetsinger et al. (1973), restriction to 94% of the full-fed controls gave higher livability and improved feed efficiency with no decline in egg production. Likewise Voitle and Harms (1974) reported that restricting the feed intake of broiler breeder hens had no effect on the rate of lay or average egg size, but feed utilization was improved. Combs et al. (1961), showed that when energy intake of laying hens were restricted to 87% and 80.6% of the productive energy intake of birds fed ad libitum, egg production was not significantly affected. However egg size was significantly reduced, the total amount of egg production was slightly less and a reduction in body weight was observed.

Auckland and Fulton (1973) offered 24 weeks old laying birds feed containing energy levels that ranged from 1200-1062 KJ ME/bird/day and the mean egg weight of the lower energy levels was significantly less than the control group given 1504 KJ ME/bird/day.

When the lowest energy diet was fortified with higher levels of protein, calcium and phosphorus egg weight significantly improved. Auckland and Fulton (1973) thus suggested that protein and or minerals as well as energy were probably limiting egg weight at the lower levels of feed intake during early stage of lay. When restriction was stopped, there was no significant difference in egg weight due to previous feeding treatment but the restricted groups tended to lay heavier eggs than continuously full-fed birds. Eggs from birds allowed lowest energy intake had significantly thinner shells. The Haugh units and shell thickness were also negatively affected by the reduced energy intake.

Guerry and Muir (1977) restricted feed intake of layers to 95, 90 or 85% of the amount consumed by the control group the previous week. Restriction started at 22 and 32 weeks of age in trials 1 and 2 respectively. A linear and significant decrease in egg production occurred but the reduced feed consumption was sufficient to compensate for the reduced production. The feed efficiency of the restricted group was numerically superior in trial 1 and significantly superior to full fed groups in trial 2. Feed restriction reduced average body weight and egg weight.

Most workers have also found that there is no significant effect of restriction on mortality (Bolton et al ., 1970; Auckland and Fulton, 1973; Kari et al., 1977). However, Bullock (1962) (cited by Bullock et al., 1963) studied mortality data from 31 restricted feeding experiments reported in literature and concluded that restricted birds show lower laying house mortality because of the higher mortality in the growing period.

GENERAL EXPERIMENTAL PROCEDURES

i. Chicks

The birds used in this experiment were Babcock B.380 pullet day-old chicks purchased from a local hatchery. Two trials of this experiment were performed with some slight modifications as were deemed necessary. The weights of all replicates were equalized on the basis of their average weight to within 0.5 gramme. The pullet chicks were reared on deep litter from hatch to 20 weeks of age. At 20 weeks they were transferred to battery cages in the layer's house.

ii. Management of Birds

Chicks were reared in the tropical type open-sided poultry house with a floor space allowance of 0.074m²/bird in accordance with the recommendations of Olomu and Offiong (1978). Heat for brooding was supplied by kerosine lanterns; two were used per replicate. The open side portions of the house were covered with polythene sheets during the first four weeks of brooding period. Feed and water were supplied as and when prescribed by each experiment from day-old to 20 weeks to all replicates. The birds were observed daily and records of mortality kept. Fortnightly records of body weight feed consumption and mortality were kept for each replicate from 0 to 20 weeks. At 8 and 20 weeks, the average commulative body weight, feed consumption, feed efficiency and total mortality were computed. After 20 weeks, all replicates were placed on the same layer ration. Records on the layers were kept for daily egg production and mortality; egg weight (average weight of all eggs laid by each replicate on one day of each week); body weight at start and end of each experiment.

Feed consumption was determined at 28 days intervals. The laying component of the study lasted 112 days for each trial.

iii. Feeds

During the brooding and growing stages feed prescribed by the experiment were offered to the birds. The major ingredients were analysed for their proximate chemical composition at the laboratories of the National Animal Production Research Institute, Shika using AOAC (1965) methods. The gross chemical composition of the major ingredients used are given in Table 1.

iv. Data Analysis

Data collected in all the experiments were subjected to analysis of variance and the statistical significance of differences between means were assessed by the application of Duncan's Multiple Range Test at 5% level of significance (Steel and Torrie, 1960).

Table 1: Proximate chemical composition of the major ingredients used in ration formulation (% air dry basis).

Ingredients	Dry matter %	Crude protein %	Ether Extract %	Crude Fibre %	Ash %	Calcium %	Total phosphorus %
Maize	90.00	8.91	3.79	2.20	1.51	0.02	0.25
Groundnut cake	92.01	45.01	7.31	13.01	5.41	0.26	0.56
Wheat bran	93.00	16.01	3.10	11.04	2.25	0.14	1.15
Soybean cake	91.00	48.50	1.12	7.40	6.15	0.27	0.62

QUALITATIVE FEED RESTRICTION

Objective

To determine the effect of qualitative feed restriction through dietary protein restriction on subsequent performances of egg type pullets.

Status of the problem

As mentioned in the introduction, feed represents 60-65 percent of the cost of producing a dozen eggs. The cost of various ingredients that constitute the feed has been on the increase, hence there is the need to reduce this cost and hence the ultimate cost of the product - eggs. One of the ways of cutting down on the cost of production is to reduce the cost of feed consumed by the pullets from hatch to point of lay. Since protein is perhaps the most expensive item in feeds, feeding of the birds on low protein diets during growth is one way of reducing the cost of feeding of the pullets and hence the cost of producing the eggs. In Nigeria, groundnut and soybean cakes are currently the major protein sources used in formulating chick and grower diets for pullet rearing, and these ingredients are very expensive feed ingredients. Efforts made to reduce the level of their inclusion in the feed will go a long way in reducing the cost of the feed and hence the cost of raising the birds. Apart from reduction in the cost of raising replacement pullets, qualitative feed restriction has also been used to delay sexual maturity of pullets in order to reduce the number of small eggs laid by pullets. Two qualitative trials were designed and executed to determine the best options and regimens for restricting protein in the diet of replacement pullets and laying chickens without adversely affecting performance.

Effect of Qualitative Feed Restriction on Performance of Replacement Pullets (0-20 weeks)

Trial 1a (Growing phase)

Objective

To determine the effect of qualitative feed restriction on the growth of replacement pullets.

Experimental

Nine-hundred day-old chicks were allocated to six triplicate treatment pens of fifty birds each. The six treatments used were as follows:

Treatment 1: 20% protein diet (0-8 weeks);
16% protein diet (9-20 weeks).
This treatment was used as the control.

Treatment 2: 16% protein diet (0-20 weeks).

Treatment 3: 12% protein diet (0-20 weeks).

Treatment 4: 16% protein diet (0-8 weeks);
12% protein diet (9-20 weeks).

Treatment 5: 20% protein diet (0-8 weeks);
12% protein diet (9-20 weeks).

Treatment 6: 20% protein diet (0-8 weeks);
16% protein diet (9-16 weeks);
12% protein diet (17-20 weeks).

The birds were managed as described under General Experimental Procedures. The composition of the diets used is given in Table 2.

See appendix 1 for the statistical analysis.

Table 2: Percentage composition of rations fed in Trials 1a and 2a.

Ingredients	Rations 1	2	3
	%	%	%
Maize	52.50	58.30	64.30
Groundnut cake	28.40	15.60	3.30
Wheat bran	15.70	23.70	30.00
Premix[a]	0.15	0.15	0.15
Common salt	0.25	0.25	0.25
Bone meal	3.00	2.00	2.00
	100.00	100.00	100.00
Calculated Nutrient levels			
Crude protein, %	20.01	16.00	12.01
Metabolizable Energy (Kcal/kg diet)	2649	2647	2649
Calcium, %	0.95	0.65	0.60
Phosphorus (available), %	0.55	0.43	0.42
Lysine, %	0.85	0.61	0.45
Methionine + Cystine, %	0.63	0.54	0.47
Crude fibre, %	6.57	5.92	5.14
Feed cost, ₦/kg diet	0.59	0.55	0.52

[a]Zoodry VM 201 premix used supplied the following per kg of ration. Vitamin A (stabilized) 10,005 I.U.; Vitamin D_3 (stabilized) 2,250 I.U.; Vitamin E (stabilized) 5.01 I.U., Vitamin K (stabilized) 2.01mg; Vitamin B_2 4.50mg; Vitamin B_6 3.0mg; Nicotinic acid 22.005mg; Calcium D-Pantothenate 6.0mg; Vitamin B_{12} 0.012mg; Choline chloride 200.10mg; D.O.T.(3,5-dinitro-ortho-toluamide) 100.05mg; Manganese 80.01 mg; Iron 50.01mg; Zinc 40.005mg; Copper 2.4mg; Iodine 1.401mg; Cobalt 0.201mg; Selenium 0.051mg.

Results

The results obtained in Trial 1 are summarised in Table 3. For the chick stage (0-8 weeks) the level of protein given to the birds was crucial to the proper growth of the birds. In terms of feed efficiency and weight gain, the low protein diet of 12% (treatment 3) significantly depressed growth performance of the birds. Treatment 3 birds also consumed significantly (P(0.05) less feed which was inefficiently utilized resulting in an average weight gain that was only 57% when compared to the birds fed the control diet. Birds fed 16% protein diet (treatments 2 and 4) were comparable to birds on 20% protein diet (treatments 1, 5 and 6) in terms of feed intake, feed efficiency and cost per unit of gain but were significantly lighter in weight than their 20% protein counterparts.

During the growing phase (i.e. 9-20 weeks) birds fed 12% crude protein from day-old still showed low performance probably due to the poor start. However treatments 4 and 5 fed 12% protein diets during the growing phase were comparable to the control birds fed 16% protein diet during this period. Cost per kilogramme gain did not differ significantly between treatments though treatment 2 was the least expensive to feed. There was no significant difference between the control birds and treatment 6 which indicates that there was no advantage in using a single step protein regimen over a two-step protein regimen during the growing stage.

When comparing the overall effect of the different protein levels fed between 0-20 weeks, treatment 6 showed no advantage of using three-stage protein regimen over two-stage protein regimen as in the control.

Likewise 16% single-stage protein regimen was comparable to the control while 12% single-stage protein regimen was significantly inferior to the control. Treatments 4 and 5 were comparable to each other but both were significantly poorer in terms of feed efficiency are weight gain when compared with the control (treatment 1) and the single step 16% protein regimen (treatment 2). In terms of cost per kilogramme gain, treatment 2 (16% protein throughout) was the least expensive but was not significantly different from the control. Only treatment 3 (12% protein throughout) was significantly more expensive than the control. Other treatments resulted in non-significant difference from the control or among themselves. Mortality rates showed significant differences, with treatment 4 having significantly higher mortality percentage than other treatments. It was unclear if the differences were attributable to dietary treatments. No post-mortem examination was carried out on the dead birds.

Summary

This trial was conducted with nine-hundred day-old replacement pullets, and their growth pattern was monitored until twenty weeks. Different combinations of isocaloric experimental diets containing 20, 16 and 12% crude protein were fed. Results indicate that:

1. A 16% crude protein diet could be fed to chicks from day old to 20 weeks without detrimental effect.
2. Feeding a ration as low as 12% crude protein was not beneficial to young chicks of 0-8 weeks old.
3. A three stage protein regimen was not advantageous over a single or two stage protein regimen.

Table 3: Effect of qualitative feed restriction on growth performance of replacement pullets in Trial 1a[1,2].

Treatment	0–8 weeks				9–20 weeks				0–20 weeks				Mortality (%)
	Feed intake (g/bird)	Feed efficiency (g feed/g gain	Weight gain (g/bird)	Feed Cost/ kg gain (₦)	Feed intake (g/bird)	Feed efficiency (g feed/ g gain)	Weight gain (g/bird)	Feed Cost/ kg gain (₦)	Feed intake (g/bird)	Feed efficiency (g feed/g gain)	Weight gain (g/bird)	Feed cost/ kg gain (₦)	
1	1219.5^{a}	3.79^{b}	322.67^{a}	2.24^{b}	4926.33^{ab}	5.65^{ab}	881.47^{ab}	3.12	6145.83^{a}	5.12^{bc}	1204.14^{a}	5.36^{bc}	4.00^{b}
2	1130.93^{ab}	4.10^{b}	277.33^{b}	2.27^{b}	4726.53^{ab}	4.49^{b}	1023.73^{a}	2.59	5857.46^{a}	4.50^{c}	1301.06^{a}	4.86^{c}	5.33^{b}
3	1038.73^{b}	5.61^{a}	185.90^{c}	2.90^{a}	4275.33^{c}	6.05^{a}	708.38^{b}	3.13	5314.06^{b}	5.96^{a}	894.28^{c}	6.03^{a}	6.67^{b}
4	1171.23^{a}	4.15^{b}	284.47^{b}	2.27^{b}	4649.57^{b}	6.67^{a}	697.85^{b}	3.51	5820.80^{a}	5.96^{a}	982.32^{bc}	5.78^{b}	10.00^{a}
5	1197.59^{a}	3.75^{b}	319.43^{a}	2.21^{b}	4629.80^{b}	6.53^{a}	711.60^{b}	3.38	5827.39^{a}	5.66^{a}	1031.03^{bc}	5.59^{b}	6.00^{b}
6	1192.97^{a}	3.83^{b}	311.23^{ab}	2.26^{b}	4980.63^{a}	6.31^{a}	794.98^{b}	3.41	6173.60^{a}	5.60^{ab}	1106.21^{ab}	5.67^{b}	4.00^{a}
SEM[3]	32.60	0.156	10.79	0.088	98.93	0.377	55.17	0.215	107.32	0.231	49.51	0.201	0.903

[1]Means obtained from 150 birds in three replicates of 50 birds each.
[2]Means within each column with different superscripts are significantly different ($P<0.05$)
[3]SEM = Standard error of the means.

4. Cost per kilogramme gain was higher for chicks reared on 12% protein from 0- to 20 weeks. During the growing stage (i.e. 9-20 weeks) there were no significant difference among treatments.

Effect of Qualitative Feed Restriction on Subsequent Laying Phase
Trial 1b (Laying phase)

Objective

To determine the effect of the different protein levels fed during the growing stage on the subsequent performance in the laying phase.

Experimental

Eight hundred and forty-six replacement pullets reared to 20 weeks (point of lay) in trial 1a were transferred to the laying house. The laying house is a tropical type open-sided poultry house provided with battery laying cages. Each cage is 30 by 35 cm and 41.5 cm high. The birds were not randomised but made to retain their growing phase groups and treatment numbers. All birds were fed the same layer ration (See table 4). Feed and water were supplied ad libitum. No artificial light was provided.

During the experimental period of 112 days (four 28-day periods) records were kept on daily egg production and mortality. The birds were individually weighed at first egg and at 36 weeks when the experiment was terminated. The ages of the birds at first egg, 5% production, 50% production and peak production were calculated (these paremeters were the averages of the ages of the three replicates when they attained the production levels for three consecutive days). On one day of each week in each 28 day-period, all eggs laid by each replicate were collected and weighed. Feed consumption was determined fortnightly.

Table 4: Percentage composition of layer's ration fed in Trials 1b and 3b.

Ingredients	%
Maize	50.00
Wheat bran	24.50
Soyabean meal	15.50
Bone meal	2.25
Oystershell	7.10
Salt	0.25
Premix[a]	0.20
DL-Methionine	0.20
	100.00
Calculated Nutrients Levels	
Crude protein, %	16.08
Metabolizable energy (kcal/kg diet)	2407
Calcium, %	3.42
Phosphorus (available), %	0.45
Lysine, %	0.92
Methionine + cystine, %	0.73
Crude fibre, %	4.39

[a]Zoodry VM 301 premix used supplied the following per kg of ration. Vitamin A (stabilized) 10,005 I.U.; Vitamin D_3 (stabilized) 2010 I.U.; Vitamin E (stabilized) 10.005 I.U.; Vitamin K 2.01mg; Vitamin B_2 4.5mg, Vitamin B_6 3.0mg; Nicotinic Acid 25.005mg; Calcium D-Pantothenate 8.01mg; Vitamin B_{12} 0.012mg; Vitamin C 20.01mg; Choline chloride 200.1mg; Manganese 100.005mg; Iron 50.01mg; Zinc 40.005mg; Copper 2.4mg; Iodine 1.401mg; Cobalt 0.201mg; Selenium 0.051mg.

Data collected during the experimental period were subjected to analysis of variance and the level of significance assessed by applying Duncan's Multiple Range Test (Steel and Torrie,1960) at 5% level of significance. Details of analysis of variance are given in Appendix 2.

Results

The results obtained from this experiment are summarized in Tables 5 and 6.

The use of different combinations of protein levels during the brooding and growing phases did not result in significant increases in the ages of the birds to maturity. The age at first egg; 5%; 50% and peak production were not significantly influenced by the level of protein fed during brooding and growing phases, though the birds on the control diet (treatment 1) attained sexual maturity earlier than the other treatments. Birds which were on treatment 5 attained the highest peak of 87.47% at 231 days of age which was not significantly different from the rest of the treatments.

The feed consumption and the egg production pattern were not significantly affected by treatment as shown in Table 6. Also the weight of the birds at first egg and at the end of the experiment were not significantly affected by treatment.

Summary

This experiment was conducted to investigate the effect of protein restriction during the rearing stage on the subsequent performance in the laying phase. The result obtained show that:

1. The levels of restriction applied in the brooding and growing phases did not have a significance effect on the laying phase.
2. Feeding a ration as low as 12% crude protein from 0-20 weeks did not significantly affect the laying performance of the birds.

Table 5: Effect of qualitative feed restriction on age and weight at maturity and feed consumption and mortality rate during lay. Trial 1b[1,2].

Treatment	Age at 1st egg (days)	Weight at 1st egg (kg/bird)	Age at 5% production (days)	Age at 50% production (days)	Age at peak production (days)	% at peak production (%)	Feed consumption from day old to 5% production (kg/bird)	Feed consumption from day old to 50% production (kg/bird)	Feed consumption 0-36 weeks (kg/bird)	Weight at 36 weeks (kg/bird)	Mortality during lay (%)
1	170	1.49	173	188	227	84.9	10.39	12.14	19.88	1.74	0.70
2	173	1.46	179	190	232	83.6	10.83	11.92	19.42	1.69	0.00
3	179	1.38	182	197	229	84.8	10.63	12.37	19.41	1.72	0.00
4	176	1.41	182	192	229	85.9	11.33	12.60	19.85	1.73	0.00
5	171	1.40	178	191	231	87.5	10.72	12.32	19.87	1.67	0.00
6	172	1.48	178	193	226	79.0	10.97	12.75	19.83	1.70	0.00
SEM[3]	4.88	0.13	5.46	3.80	1.41	3.09	0.66	0.53	0.67	0.08	0.28

[1]Means obtained from 150 birds in three replicates of 50 birds each.
[2]Means for all parameters are not significantly different(P>0.05).
[3]SEM = Standard error of the means.

Table 6: Effect of qualitative feed restriction on laying house performance in Trial 1b.[1,2]

Treatment	Hen-day egg production (%)	Hen housed egg production (%)	Feed consumption (g/bird/day)	Feed per dozen egg (kg)	Feed per kg egg (kg)
1	61.72	60.60	116.05	2.53	1.62
2	56.33	55.33	112.11	2.62	1.68
3	54.09	52.46	115.43	2.89	1.86
4	59.77	58.06	112.93	2.83	1.78
5	57.54	55.19	114.29	2.68	1.69
6	50.86	58.57	111.21	3.05	3.05
SEM[3]	4.12	4.09	8.35	0.44	0.45

[1]Means obtained from 150 birds in three replicates of 50 birds each.

[2]Means for all parameters are not significantly different($P > 0.05$)

[3]SEM - Standard Error of the means.

3. Economic gains could not be made by feeding a ration as low as 12% protein from 0-20 weeks because it was significantly more expensive to feed such birds to point of lay (see table 3).

Effect of Qualitative Feed Restriction on Performance of Replacement Pullets (0-20 weeks).

Trial 2a (Growing phase)

Objectives

a. To further confirm the effect of qualitative feed restriction on the growth performance of egg-type pullets.
b. To determine the effect of step-up protein restriction on the growth performance of egg-type pullets.

Experimental

Four hundred and eighty day-old chicks were randomly allocated to twenty-four pens with twenty birds per pen. Three such pens constitute a treatment. In this trial treatment 5 of trial 1 was dropped because there was no advantage in using a three stage regimen over a two stage. Three new treatments (treatments 6, 7 and 8) were however in corporated to make a total of eight treatments to confirm results of the first trial and to try out other options. The treatments were as follows:

Treatment 1: 20% protein diet (0-8 weeks); 16% protein diet (9-20 weeks). This treatment was used as the control.

Treatment 2: 16% protein diet (0-20 weeks).

Treatment 3: 12% protein diet (0-20 weeks).

Treatment 4: 16% protein diet (0-8 weeks); 12% protein diet (9-20 weeks).

Treatment 5: 20% protein diet (0-8 weeks); 12% protein diet (9-20 weeks).

Treatment 6: 12% protein diet (0-8 weeks); 16% protein diet (9-20 weeks).

Treatment 7: 12% protein diet (0-8 weeks); 20% protein diet (9-20 weeks).

Treatment 8: 16% protein diet (0-8 weeks); 20% protein diet (9-20 weeks).

The birds were managed as described under General Experimental Procedures. The composition of the diets used is given in Table 2. See Appendix 3 for the statistical analysis.

Results

The results obtained in Trial 2a are summarized in Table 7. The results of this experiment further confirm the earlier results in Trial 1a. A protein level of between 16 and 20% promotes proper development of the pullets during the brooding stage of 0-8 weeks. Birds fed 16 and 20% crude protein (treatments 1, 2, 4, 5 and 8) were more efficient feed converters than those fed 12% protein (Treatments 3, 6 and 7). Treatments 3, 6 and 7 also had the lowest weight gains.

During the growing phase (i.e. 9-20 weeks) the treatments on step-down and single stage protein regimens (i.e. treatments 1-5)also confirmed results obtained in trial 1a. Protein level fed after eight weeks was found to be less crucial than that before eight weeks. The treatments involving step-up protein regimens (treatment 6-8) showed a different trend from the step-down treatments. Compensatory growth was evident in these treatments, the level of compensation depended on the gradient of stepping. Birds on these treatments gained

Table 7: Effect of qualitative feed restriction on growth performance of replacement pullets in Trial 2a[1,2].

Treatment	0–8 weeks				9–20 weeks				0–20 weeks				Mortality (%)
	Feed intake (g/bird)	Feed efficiency (g feed/ g gain)	Weight gain (g/bird)	Feed cost/ kg gain (N)	Feed intake (g/bird)	Feed efficiency (g feed/ g gain)	Weight gain (g/bird)	Feed cost/ kg gain (N)	Feed intake (g/bird)	Feed efficiency (g feed/ g gain)	Weight gain (g/bird)	Feed cost/ kg gain (N)	
1	1110.60^{ab}	3.37^{c}	330.94^{ab}	1.99^{a}	4869.13^{cd}	5.60^{c}	869.73^{ab}	3.10^{a}	5979.73^{c}	4.99^{d}	1200.67^{a}	5.09^{a}	2.78
2	1065.20^{bc}	3.98^{b}	267.50^{c}	2.20^{b}	4958.23^{cd}	6.17^{b}	803.77^{b}	3.41^{bc}	6023.43^{bc}	5.62^{c}	1071.27^{bc}	5.61^{b}	5.00
3	1023.87^{c}	4.82^{a}	212.39^{d}	2.50^{cd}	4968.23^{cd}	7.45^{a}	667.03^{c}	3.86^{e}	5992.10^{bc}	6.82^{a}	879.42^{e}	6.36^{d}	3.33
4	1118.30^{ab}	4.03^{b}	277.22^{c}	2.23^{b}	4935.83^{cd}	7.31^{a}	675.00^{c}	3.79^{e}	6054.13^{bc}	6.36^{b}	952.22^{de}	6.02^{cd}	0.00
5	1158.37^{a}	3.17^{c}	366.00^{a}	1.87^{a}	5128.00^{bc}	7.14^{a}	719.27^{c}	3.70^{de}	6286.37^{ab}	5.80^{c}	1085.27^{bc}	5.57^{b}	6.67
6	955.00^{d}	4.88^{a}	195.94^{d}	2.53^{d}	4756.67^{d}	5.78^{bc}	825.33^{b}	3.19^{ab}	5711.67^{c}	5.60^{c}	1021.27^{cd}	5.72^{bc}	0.00
7	936.63^{d}	4.71^{a}	198.94^{d}	2.44^{cd}	5524.70^{a}	5.94^{bc}	931.83^{a}	3.50^{cd}	6461.33^{a}	5.72^{c}	1130.77^{ab}	5.94^{bc}	3.33
8	1092.50^{ab}	4.19^{b}	294.34^{bc}	2.32^{bc}	5325.00^{ab}	6.19^{b}	865.00^{ab}	3.65^{cde}	6417.50^{a}	5.72^{c}	1159.34^{ab}	5.97^{bcd}	2.22
SEM[3]	23.63	0.125	14.81	0.068	105.89	0.178	24.84	0.089	117.60	0.146	28.10	0.140	1.88

[1] Means obtained from 60 birds in three replicates of 20 birds each.

[2] Means within each column with different superscripts are significantly different ($P<0.05$).

[3] SEM = Standard error of the means.

weights that were not significantly different from the control group. In terms of feed efficiency only treatment 8 was significantly less efficient than the control group. This may indicate that there was no need to step-up the protein when chicks were started on 16% protein, as 16% protein from 0-20 weeks was found comparable to the control in the two studies conducted. In terms of feed intake birds on 20% protein consumed more feed than those on lower protein levels between 9-20 weeks.

In respect of the overall effect of the different protein levels fed between 0-20 weeks, the control was found to be the most efficient and the single stage 12% protein was found to be the most inferior. If chicks were started very poorly and later stepped up by improving the protein content of the mash a marked improvement was observed due to compensatory growth as in treatments 6 and 7 as compared with treatment 3.

Mortality rate did not show any significant difference and there was no post-mortem examination carried out on the dead birds. With reference to the cost per kilogramme gain during the brooding phase (0-8 weeks), the best economic gain was achieved in treatments 1 and 5 that were on 20% protein diet at this period. Treatments 2, 4 and 8 that were on 16% protein diet between 0-8 weeks performed next and treatments 3, 6 and 7 that were on 12% protein diet between 0-8 weeks were the worst which confirmed the results obtained in trial 1a. During the growing stage (9-20 weeks) the control ration was most efficient, and treatment 3 (12% protein throughout) the worst. In the step-up protein regimen treatments, treatment 6 (12% protein 0-8 weeks; 16% protein 9-20 weeks) was the only treatment comparable to the control. The other two treatments were significantly different from the control. The control still proved superior when the overall effect of the treatments were considered (i.e. 0-20 weeks).

Stepping up of the protein levels of the chicks during growth did not indicate any economic gain in this work.

Summary

This trial was conducted with four hundred and eight day-old replacement chicks and their growth pattern was monitored until twenty weeks. Different combinations of isocaloric experimental diets containing 20, 16 and 12% crude protein were fed.

Results indicate that:

1. A 16% crude protein diet could be fed to chicks from day old to 20 weeks without detrimental effect.
2. Feeding a ration as low as 12% crude protein was not beneficial to young chicks of 0-8 weeks old.
3. Birds fed low protein diet exhibited compensatory growth when higher protein diets were provided and attained weights comparable to control birds.

Effect of Qualitative Feed Restriction on Subsequent Laying Phase
Trial 2b (Laying phase)

Objectives

1. To further confirm the effect of the different protein levels fed during the growing stage on subsequent laying phase.
2. To determine the effect of step-up and step-down protein regimens during the growing stage on the subsequent laying phase.

Experimental

Four hundred and sixty-two replacement pullets reared to 20 weeks (point of lay) were transfered to the laying house as described in Trial 1b. The birds were not randomised but made to retain their growing phase treatment numbers. All birds were fed the same layer's ration shown in Table 8. Feed and water were supplied ad libitum. No artificial light was provided.

Table 8: Percentage composition of layer's ration fed in Trials 2b and 4b.

Ingredients	%
Maize	52.15
Groundnut cake	18.25
Wheat bran	19.70
Bone meal	2.15
Limestone	7.10
Salt	0.25
Premix[a]	0.20
DL-Methionine	0.20
	100.00
Calculated Nutrient Levels:	
Protein, %	16.01
Metabolizable energy (kcal/kg diet)	2448.62
Calcium, %	3.41
Phosphorus (available), %	0.43
Lysine, %	0.63
Methionine + cystine, %	0.61
Crude fibre, %	5.69

[a]Premix - a commercial product with composition as shown in Table 4.

During the experimental period of 112 days (four-28 day periods) records were kept as described in Trial 1b. Details of analysis of variance are given in Appendix 4.

Results

The results obtained in this experiment are summarized in Tables 9 and 10.

The use of different combinations of dietary protein levels during the brooding and growing phases did not result in significant increase in weight at first egg, age at 50% production, weight at the end of the experiment (i.e. weight at 36 weeks) and mortality during lay. On the other hand the treatments did significantly affect the age at first egg, age at 5% production and feed consumed to 5 and 50% production.

The birds reared on 12% protein from 0-20 weeks (i.e. treatment 3) were significantly poorer to the rest of the treatments, followed by treatment 4 (16% protein 0-8 weeks; 12% protein 9-20 weeks). These birds attained sexual maturity late but were able to compensate this late start before the experiment was terminated (See Table 10). Treatments 5 and the control were comparable and there was no significant difference in all the parameters measured (see Tables 9 and 10).

It was observed that stepping up the protein level offered birds from 12% at day old to 16 or 20% from 9 weeks improved the performance of the birds. This is evident when treatments 6 and 7 were / compared to treatment 3. Although the differences were not significant for all parameters it was evident that the improved nutrition during the growing stage (i.e. 9-20 weeks) improved some parameters measured such as age at 1st egg in treatment 6 and age at 50% production in treatment 7 (see table 9), on the laying house performance feed per dozen eggs for the first period was significantly improved by stepping

Table 9: Effect of qualitative feed restriction on age, weight at maturity feed consumption and mortality rate during lay in Trial 2b[1,2].

Treatment	Age at 1st egg (days)	Weight at 1st egg (kg/bird)	Age at 5% production (days)	Age at 50% production (days)	Age at peak production (days)	% at peak production (%)	Feed consumed to 5% production (kg/bird)	Feed consumed to 50% production (kg/bird)	Feed consumption 0-36 weeks (kg/bird)	Weight at 36 weeks (kg/bird)	Mortality during lay (%)
1	160^{b}	1.48	162^{e}	183	192	76.0	7.87^{c}	10.44^{c}	14.06	1.74	8.51
2	160^{b}	1.45	169^{bcd}	190	211	77.6	8.81^{ab}	11.36^{ab}	14.26	1.71	1.66
3	172^{a}	1.38	175^{a}	195	220	75.6	9.65^{a}	11.87^{a}	14.74	1.70	7.12
4	168^{ab}	1.40	173^{ab}	190	203	77.7	9.14^{ab}	11.21^{ab}	14.09	1.69	5.19
5	160^{b}	1.41	165^{de}	183	204	77.2	8.67^{bc}	10.79^{bc}	14.71	1.73	7.22
6	170^{b}	1.53	172^{abc}	190	211	70.0	8.90^{ab}	10.87^{bc}	13.64	1.71	5.00
7	165^{ab}	1.40	166^{cde}	189	211	70.0	8.87^{ab}	11.54^{ab}	13.68	1.74	8.33
8	161^{b}	1.44	167^{bcde}	188	195	78.3	9.11^{ab}	11.28^{ab}	13.60	1.67	5.00
SEM[3]	2.70	0.95	2.17	2.83	7.41	3.46	0.29	0.39	0.28	0.04	2.28

[1] Means obtained from 60 birds in three replicates of 20 birds each.
[2] Means within each column with different superscripts are significantly different ($P<0.05$).
[3] SEM = Standard error of the means.

Table 10: Effect of qualitative feed restriction on laying house performance in Trial 2b[1,2].

Treatment	Hen-day egg production (%)	Hen-housed egg production (%)	Feed consumption period 1(g/bird/day)	Feed per doz. eggs period 1 (kg)	Feed consumption period 2 (g/bird/day)	Feed per doz. eggs period 2 (kg)	Feed consumption period 3 g/bird/day	Feed per doz. eggs period 3 (kg)	Feed consumption period 4 g/bird/day	Feed per doz. eggs period 4 (kg)
1	63.18	61.29	116.13^{ab}	3.26^{d}	111.65^{bcd}	2.65	121.89	3.86	124.27	2.99
2	63.18	62.75	117.30^{ab}	4.24^{bcd}	113.11^{abc}	2.61	123.41	3.83	131.08	3.11
3	60.73	57.75	107.34^{c}	8.14^{a}	112.54^{abcd}	2.76	122.10	3.14	123.45	3.09
4	61.04	58.93	119.85^{a}	5.88^{b}	120.65^{a}	3.08	122.27	3.61	122.74	3.36
5	69.26	67.29	115.94^{ab}	3.71^{cd}	119.29^{ab}	2.70	124.39	2.79	131.08	3.18
6	62.10	60.89	111.30^{bc}	5.25^{bc}	103.50^{d}	2.45	118.62	3.23	122.87	3.35
7	61.45	59.40	112.49^{bc}	4.13^{bcd}	111.26^{bcd}	2.86	122.92	3.32	125.42	3.27
8	66.68	65.75	116.93^{ab}	3.68^{cd}	106.09^{cd}	2.51	118.16	3.00	124.41	2.97
SEM[3]	3.20	2.99	2.13	0.62	3.10	0.14	2.60	0.28	3.70	0.14

[1] Means obtained from 60 birds in three replicates of 20 birds each.
[2] Means with each column with different superscripts are significantly different ($P<0.05$).
[3] SEM = Standard error of the means.

up from 12 to 16 or 20% protein.

Stepping up the protein from 16% to 20% from 9 to 20 week did not significantly improve age at first egg, age at 5% production, feed consumed to 5% production, feed consumed to 50% production, nor feed per dozen eggs for the first two months in lay. This was evident when treatments 2 and 8 were compared in Tables 9 and 10. Dietary treatments was observed not to affect egg production from the third period of lay (See table 10).

Summary

This experiment was conducted to investigate the effect of different protein restriction on subsequent egg production. The result obtained show that:

The levels of restriction used during brooding and growing phases did not have a significant effect on the laying phases after two months in lay, (i.e. after period 2).

QUANTITATIVE FEED RESTRICTION

Objective

To determine the effect of quantitative feed restriction on subsequent laying performance of egg-type pullets.

Status of the problem

The cost of the various ingredients that constitute the feed is constantly increasing. To maintain customer patronage, it is important that egg price must be reasonably low. Distinct from the qualitative or protein restriction procedure, another way of cutting down on production cost is to reduce the quantity of feed made available to the birds for consumption during the growing period (i.e. 9-20 weeks). A proportion of their ad libitum feed can be made available to the birds at this period or total withdrawal of feed on certain days. By reducing the quantity of feed offered to the birds this reduces the cost of bringing the birds to lay and hence the cost of eggs.

Two quantitative feed restriction studies were designed and executed . In the first trial, (Trial 3) four treatments were used. Restriction started at the 9th week and was terminated at the 20th week. The different treatments used were as follows:

Treatment 1: Feed available ad libitum every day.

Treatment 2: Feed available every other day (skip a day).

Treatment 3: Feed available every two days and no feed on the third day (skip one day after every two days).

Treatment 4: Feed approximately 75% of feed consumed by treatment 1 the previous week.

For the second quantitative trial (Trial 4) treatment 4 was dropped as it was found to be very labour intensive and therefore involved more costs.

Consequently treatments 1 to 3 were repeated to further confirm the findings of trial 3.

Effect of Quantitative Feed Restriction on Performance of Replacement Pullets (0-20 weeks)

Trial 3a (Growing phase)

Objective

To determine the effect of quantitative feed restriction on the growth of replacement pullets.

Experimental

Six hundred day-old pullet chicks were allocated to four triplicate treatment pens of fifty birds each and were subjected to the following treatments:-

Treatment 1: 20% protein (0-8 weeks); 16% protein (9-20 weeks); feed available ad lib. from 0-20 weeks. This served as the control treatment.

Treatment 2: 20% protein (0-8 weeks ad lib. feeding); 16% protein (9-20 weeks); feed available ad lib. every other day.

Treatment 3: 20% protein (0-8 weeks ad lib. feeding); 16% protein (9-20 weeks); feed available ad lib. every two days followed by one day of no feed.

Treatment 4: 20% protein (0-8 weeks ad lib. feeding); 16% protein (9-20 weeks); approximately 75% of feed consumed by treatment 1 the previous week was made available.

Birds were managed and data obtained treated as described under the General Experimental Procedure. The composition of the diets is given in Table 11.

Parameters measured included feed consumption, weight gain, feed efficiency, and feed cost per kilogramme gain. Details of statistical analysis are given in Appendix 5.

Results

The results obtained in Trial 3 are summarized in table 12. During the first phase of the growing period (i.e. 0-8 weeks) there was no significant difference in all the parameters measured. This was expected as there was no restriction and all treatments were fed ad libitum.

In the second phase of the growing period (i.e. 9-20 weeks) treatment 1 (control) consumed significantly more feed than the feed restricted groups. The most restricted group (treatment 2) consumed about 30% less feed than the control birds. This is quite a substantial savings in feed. The treatment did not significantly affect the efficiency of feed utilization. The feed efficiency ranged between 5.65 for the control group of birds and 5.30 for treatment 4. In terms of weight gain birds in the control group gained significantly more wieght than treatments 2 and 3 and had a comparable weight with treatment 4. Feed cost per kilogramme gain did not show significant differences. Mortality was highest ($P<0.05$) with the group that was most restricted (treatment 2) and this was mainly due to pecking.

The results of the overall rearing period (i.e. 0-20 weeks) showed a significant saving in feed as the restricted groups consumed significantly less feed than the control group of birds. Treatment 2 (skip a day) consumed significantly less (approx. 24%) less feed than the control birds to bring them to 20 weeks. This is a substantial feed saving when compared to the control birds that were fed ad libitum.

Feed efficiency and feed cost per kilogramme gain did not differ significantly amongst treatments. Control birds were significantly heavier than the restricted groups. Birds in treatment 1 (i.e. control birds) were significantly(about 20%) heavier than the most restricted group (treatment 2).

Summary

This trial was conducted with day old replacement pullets and their growth pattern was monitored until they were 20 weeks of age. Feed provided to the birds was restricted between 9 to 20 weeks of age. Results indicated that:

1. Quantitative feed restriction resulted in significant decrease in feed consumed and weight gained.
2. Quantitative feed restriction did not affect both the efficiency of feed utilization and feed cost per unit gain in weight.

Table 11: Percentage composition of chick and grower rations used in Trials 3a and 4a.

Ingredients	Chick Mash %	Grower Mash %
Maize	52.50	58.30
Groundnut cake	28.40	15.60
Wheat bran	15.70	23.70
Premix[a]	0.15	0.15
Common salt	0.25	0.25
Bone meal	3.00	2.00
Total	100.00	100.00
Calculated Nutrient Composition		
Crude protein, %	20.00	16.00
Metabolizable energy (Kcal/kg diet)	2645	2647
Calcium, %	0.95	0.63
Phosphorus (available), %	0.55	0.43
Lysine, %	0.85	0.61
Methionine + Cystine, %	0.63	0.54
Crude fibre, %	5.72	5.92

a = See table 2 for composition.

Table 12: Effect of quantitative feed restriction on growth performance of replacement pullets Trial 3a.[1,2]

Treatment	Feed intake (g/bird)	Feed efficiency (g feed/ g gain)	Weight gain (g/bird)	Feed Cost/ kg gain ₦	Mortality (%)
0-8 Weeks					
1	1219.50	3.79	322.67	2.24	1.00
2	1179.57	3.45	342.80	2.03	1.00
3	1164.40	3.71	313.47	2.19	1.00
4	1156.07	3.61	321.07	2.13	1.33
SEM[3]	17.63	0.10	10.49	0.06	0.11
9-20 Weeks					
1	4926.33[a]	5.65	881.47[a]	3.08	3.00[b]
2	3470.07[b]	5.33	653.48[b]	2.93	11.00[a]
3	3848.37[b]	5.62	688.73[b]	3.06	3.67[b]
4	3805.73[b]	5.30	717.43[ab]	2.92	2.67[b]
SEM[3]	123.65	0.30	51.72	0.16	0.52
0-20 Weeks					
1	6145.83[a]	5.12	1204.13[a]	5.32	4.00[b]
2	4649.63[b]	4.68	996.28[b]	4.96	12.00[a]
3	5012.77[b]	5.01	1002.87[b]	5.25	4.67[b]
4	4961.80[b]	4.78	1038.50[b]	5.05	4.00[b]
SEM[3]	119.90	0.17	44.67	0.15	0.77

[1]Means obtained from 150 birds in three replicates of 50 birds each.

[2]Means within each column with different superscript are significantly different ($P<0.05$).

[3]SEM = Standard error of the means.

Effect of Quantitative Feed Restriction on Subsequent Laying Phase (20-36 weeks)

Trial 3b (Laying phase)

Objective

To determine the effect of different levels of quantitative feed restriction during the growing phase on subsequent egg production.

Experimental

Five hundred and sixty three replacement pullets reared to 20 weeks (point of lay) in trial 3a were transferred to the laying house as described in Trial 1b. The birds were not randomized but made to retain their growing phase treatment groups. All birds were fed the same layer's ration as shown in table 4. Feed and water were supplied ad libitum. No artificial light was provided.

During the experimental period of 112 days (four 28-day periods) records were kept on daily mortality and egg production; weekly egg weight (average weight of egg laid by each group in one day of each week); body weight at start and end of experiment. Feed consumption was determined fortnightly.

Data collected during the experimental periods were subjected to analysis of variance and the details of analysis of variance are given in Appendix 6.

Results

The results obtained in the experiment are summarized in tables 13, 14 and 15. The use of quantitative feed restriction during the growing phase significantly affected the weight of the birds at 20 weeks (i.e. point of lay).

Table 13: Effect of quantitative feed restriction on age, weight at maturity, feed consumption and mortality rate during lay in Trial 3b[1,2].

Treatment	Weight at 20 weeks (kg/bird)	Age at 1st egg (days)	Age at 5% production (days)	Age at 50% production (days)	Age at peak production (days)	% at peak production (%)	Feed consumption from day old to 5% production (kg/bird)	Feed consumption from day old to 50% production (kg/bird)	Feed Consumption 0-36 weeks (kg/bird)	Weight at 36 weeks (kg/bird)	Mortality during lay (%)
1	1.24[a]	170	173	188	227	84.9	10.34	12.14	19.88	1.74[a]	0.69
2	1.03[b]	175	180	192	233	82.8	9.83	11.48	18.61	1.54[b]	0.69
3	1.04[b]	174	179	193	230	84.9	9.90	11.54	18.78	1.55[b]	0.72
4	1.07[b]	173	179	191	233	83.9	9.59	10.91	18.21	1.58[b]	0.00
SEM[3]	0.05	3.58	5.03	4.43	4.04	1.72	0.60	0.57	0.99	0.04	0.61

[1]Means obtained from 150 birds in three replicates of 50 birds each.
[2]Means within each column with different superscripts are significantly different ($P<0.05$)
[3]SEM = Standard error of the means.

Table 14: Feed consumption of quantitatively restricted laying chickens Trial 3b.[1,2]

Treatment	Feed Consumption 0-20 Weeks (kg/bird)	Feed Consumption 20 weeks-5% production (kg/bird)	Feed Consumption 20 Weeks-50% production (kg/bird)	Feed consumption 20-36 Weeks (kg/bird)
1	6.15[a]	4.19	5.99	13.73
2	4.65[b]	5.18	6.83	13.96
3	5.01[b]	4.89	6.53	13.77
4	4.96[b]	4.63	5.95	13.25
SEM[3]	0.12	0.55	0.61	0.98

[1] Means obtained from 150 birds in three replicates of 50 birds each

[2] Means within each column with different superscripts are significantly different ($P<0.05$).

[3] SEM = Standard error of the means.

Table 15: Effect of quantitative feed restriction on laying house performance of chickens in Trial 3b.[1,2]

Treatment	Hen-day egg production (%)	Hen-housed egg production (%)	Feed Consumption (g/bird/day)	Feed per dozen egg (kg)	Feed per kg egg (kg)
1	61.72	60.60	117.05	2.51	1.65
2	56.74	55.20	111.67	2.87	1.85
3	55.17	54.06	110.17	2.63	1.79
4	56.98	56.02	111.87	2.52	1.60
SEM[3]	2.75	3.15	4.82	0.75	0.11

[1]Means obtained from 150 birds in three replicates of 50 birds each.
[2]Means for all parameters are not significantly different (P>0.05).
[3]SEM = Standard error of the means.

The control birds were significantly heavier than the restricted groups. The control birds were about 20% heavier than the lightest group (Treatment 2 birds). The type of restriction given to the birds during growth did not significantly affect the age of the birds at first egg, 5%, 50% and peak production. However, there was a significant decrease in the weight of the birds both at 20 weeks and at the end of the experiment. Although the feed consumption of the birds from hatch to 5%, 50% and at the end of the experiment did not show any significant differences, it is evident in table 14 that when restriction was terminated at 20 weeks, the restricted birds consumed slightly more feed than the control birds. The difference in consumption gradually became narrower by the end of the experiment. Quantitative feed restriction did not have a significant effect on hen-day egg production, hen-housed egg production, feed consumption and the efficiency of feed for egg production as shown in table 15. The efficiency of feed for egg production was slightly better with treatments 1 and 4 than the other two.

Summary

This work was done to investigate the effect of quantitative feed restriction on subsequent egg production. The results obtained show that:

1. The level of restriction utilized during the growing phase did not have a significant effect on the laying phase.

Effect of Quantitative Feed Restriction on Performance of Replacement Pullets (0-20 weeks)

Trial 4a (Growing phase)

Objective

To further assess the effect of quantitative feed restriction on the growth of replacement pullets.

Experimental

One hundred and eighty day-old chicks were allocated to three replicate treatments of twenty birds each and were subjected to the following treatments:-

Treatment 1: (Control) 20% protein (0-8 weeks); 16% protein (9-20 weeks); feed available *ad libitum* from 0-20 weeks.

Treatment 2: 20% protein (0-8 weeks *ad lib.* feeding); 16% protein (9-20 weeks, feed available every other day).

Treatment 3: 20% protein (0-8 weeks *ad lib.* feeding); 16% protein (9-20 weeks, feed available every two days followed by one day of no feed).

The rations were fed as listed above, birds were managed as described under the General Experimental Procedure. The composition of the rations is given in Table 11. See Appendix 7 for statistical analysis.

Results

Results obtained in Trial 4 are summarized in Table 15. There were no significant differences in feed intake, feed efficiency, weight gain and cost per unit in weight during the period 0-8 weeks.

This was expected as there was no restriction during this period. Food and water were available ad libitum.

During the restriction period (i.e. 9-20 weeks) the amount of feed consumed by the control birds (treatment 1) was significantly higher than those consumed by the more restricted group (treatment 2). This restricted group consumed about 77% of the feed consumed by the control birds which shows a lot of savings in feed. However feed consumed by the group fed every two days before the feed withdrawal on the third day was similar to that of the control birds. In terms of feed efficiency and weight gain the restricted groups (treatments 2 and 3) were significantly inferior to the control birds. Treatment 2 and 3 were 34% and 18% lighter than the control birds respectively. Cost per unit gain and mortality during this period did not show any significant difference.

For period 0-20 weeks, there was still a significant difference between feed intakes of the control and the skip-a-day treatments. There was no significant difference between the control and the skip-after-every two days (treatment 3) feeding regimen. The average weight of the control birds was significantly heavier than that of the restricted groups. The weight gained by the control birds, skip-a-day and skip after every two days feeding were 1.20, 0.93 and 1.08 kilogrammes respectively. Feed efficiency, cost per unit gain and mortality did not show any significant differences among treatments. The low mortality recorded in this trial was as a result of early debeaking of the birds as against the high mortality in Trial 3a.

Summary

This trial was conducted to reconfirm the previous results in trial 3a. Feed was quantitatively restricted to the birds between 9 to 20 weeks of age.

Results indicate that:

1. Quantitative feed restriction resulted in significant decrease in feed consumed and weight gained especially during the second phase and the entire 20-week period.
2. Quantitative feed restriction did not affect the cost per unit gain in weight of the birds throughout the first and second phases.
3. Feed efficiency was significantly better for the control birds than for the restricted birds during the restriction period (i.e. 9-20 weeks).

Table 16: Effect of quantitative feed restriction on growth performance of replacement pullets in Trial 4a[1,2]

Treatment	Feed intake (g/bird)	Feed efficiency(g feed/g gain)	Weight gain (g/bird)	Feed Cost/kg gain (₦)	Mortality (%)
0-8 Weeks					
1	1110.60	3.37	330.94	1.98	0.00
2	1177.57	3.28	359.00	1.94	0.00
3	1175.17	3.18	371.06	1.87	0.00
SEM[3]	23.98	0.09	16.07	0.05	0.00
9-20 Weeks					
1	4869.13[a]	5.60[b]	869.73[a]	3.09	2.78
2	3708.67[b]	6.49[a]	571.67[b]	3.53	0.00
3	4268.33[ab]	6.04[a]	706.67[b]	3.38	1.11
SEM[3]	132.93	0.18	29.85	0.11	1.01
0-20 Weeks					
1	5979.70[a]	4.98	1200.68[a]	5.07	2.78
2	4886.23[b]	5.25	930.67[b]	5.52	0.00
3	5443.50[ab]	5.05	1077.72[b]	5.21	1.11
SEM[3]	145.01	0.11	39.75	0.14	0.93

[1]Means obtained from 60 birds in three replicates of 20 birds each.

[2]Means within each column with different superscripts are significantly different ($P<0.05$).

[3]SEM = Standard error of the means.

Effect of Quantitative Feed Restriction on subsequent laying phase (20-36 weeks)

Trial 4b (Laying phase)

Objective

To further assess the effect of different levels of quantitative feed restriction during the growing phase on subsequent egg production.

Experimental

One hundred and seventy-seven replacement pullets reared to 20 weeks (point of lay)in trial 4a were transferred to the laying house as described in Trial 1b. The birds were not randomized but retained in their growing phase treatment groups. All birds were fed the same layer's ration. (See Table 8). Feed and water were supplied ad libitum. No artificial light was provided.

During the experimental period of 112 days (four 28-day periods) records were kept on daily mortality and egg production, weekly egg weight, body weight at start and end of experiment. Feed consumption was determined fortnightly. Data collected during the experimental period were subjected to analysis of variance and the statistical significance assessed as indicated under General Experimental Procedure. Details of analysis of variance are given in Appendix 8.

Results

The results obtained in this experiment are summarized in Tables 17, 18 and 19. The results of this trial confirmed the results of the previous trial on the effect of quantitative feed restriction on subsequent egg production.

Table 17: Effect of quantitative feed restriction on age, weight at maturity feed consumption and mortality rate during lay in Trial 4b[1,2].

Treatment	Weight of birds at 20 weeks (kg/bird)	Age at 1st egg (days)	Age at 5% production (days)	Age at 50% production (days)	Age at peak production (days)	% at peak production (%)	Feed consumption from day old to 5% production (kg/bird)	Feed consumption from day old to 50% production	Feed consumption 0-36 weeks (kg/bird)	Weight of birds at 36 weeks (kg/bird)	Mortality during lay (%)
1	1.24[a]	160	162	183	192[b]	76.0	7.87	10.44	14.06	1.74[a]	6.51
2	0.97[b]	167	169	190	205[a]	76.0	7.54	9.92	13.86	1.59[b]	8.33
3	1.12[ab]	164	167	183	197[b]	82.5	8.30	10.00	14.21	1.60[b]	13.33
SEM[3]	0.04	3.51	3.40	3.40	3.14	3.38	0.34	0.38	0.25	0.02	2.38

[1]Means obtained from 60 birds in three replicates of 20 birds each.
[2]Means within each column with different superscripts are significantly different (P<0.05).
[3]SEM = Standard error of the means.

Table 18: Feed consumption of quantitatively restricted laying chickens, Trial 4b.[1,2]

Treatment	Feed Consumption 0-20 weeks (kg/bird)	Feed Consumption 20 weeks-5% production (kg/bird)	Feed Consumption 20 weeks-50% production (kg/bird)	Feed Consumption 20-36 Weeks (kg/bird)
1	5.98[a]	1.89	4.46	8.08
2	4.87[b]	2.67	5.05	5.99
3	5.44[ab]	2.86	4.56	6.77
SEM[3]	0.15	0.53	0.57	0.72

[1]Means obtained from 60 birds in three replicates of 20 birds each.

[2]Means within each column with different superscripts are significantly different ($P<0.05$).

[3]SEM = Standard error of the means.

Table 19: Effect of quantitative feed restriction on laying house performance of chickens in Trial 4b[1,2].

Treatment	Hen-day egg production (%)	Hen-housed egg production.(%)	Feed Consumption (g/bird/day)	Feed per dozen egg (kg)	Feed per kg egg (kg)
1	63.18	61.29	118.49	3.10	2.07
2	62.84	60.71	118.07	3.38	2.20
3	66.06	62.05	118.83	3.12	2.04
SEM[3]	4.15	3.52	2.35	0.37	0.15

[1]Means obtained from 60 birds in three replicates of 20 birds each.
[2]Means for all parameters are not significantly different (P>0.05).
[3]SEM = Standard error of the means.

Restriction of feed between 9-20 weeks had a significant effect on the weight of the birds at 20 weeks. The weight of the birds under skip after a day feeding regimen (treatment 2) was about 80% of the weight of the control birds. These lighter birds would require less feed for body maintenance thereby reducing the cost of egg production. This difference in weight was reduced to about 92% of the weight of control birds at 112 days after full feeding commenced. This difference was still significantly different from the control birds. Ages at first egg, 5%, 50% and peak production did not show any significant differences. Feed consumption of the birds to 5%, 50% production and to the end of the experiment (36 weeks of age) showed no significant difference but the restricted birds consumed more feed than the control birds during the laying periods as shown in Table 18. Treatment 2 birds(skip-a-day feeding) consumed 0.78, 0.59, 0.99 kg more feed to 5%, 50% and end of experiment respectively than the control birds.

Hen-day egg production, hen-housed egg production, feed consumption, feed per dozen eggs and feed per kilogramme egg did not exhibit any significant differences.

The mortality during lay was high for all treatments but there were no significant differences between treatment means.

Summary

This work was done to further evaluate the effect of quantitative feed restriction on subsequent egg production. The results obtained confirmed the earlier finding that the level of restriction utilized during the growing phase did not have a significant effect of the laying phase.

GENERAL DISCUSSION

In the two trials on the effect of qualitative feed restriction of pullets, a crude protein level of 12% was found to be inadequate to support the growth of birds between 0-8 weeks, but could be used for birds between 9-20 weeks. This is in agreement with the findings of Carlson and Nelson (1981), who recommended that diets no higher than 12% protein need be used for growing layer type pullets after 10 weeks of age. The birds on 12% protein from day-old grew poorly. In terms of feed intake, birds fed 12% protein consumed significantly (P(0.05) less feed than their counter-parts on 20 or 16% protein because of their relative small size. The less the feed consumed the less the weight gained by these groups and hence the less the efficiency of feed utilization. Cost per kilogramme gain in weight was also significantly (P(0.05) higher than their 16 or 20% protein counterparts. This clearly shows that pullets require a protein level higher than 12% between 0-8 weeks for proper growth as indicated by Scott et al. (1976) and NRC (1984). In the case where low protein level had to be used as a starter diet for replacement pullets, the amino-acid content had to be adjusted to meet recommended levels as reported by Maurice et al. (1982).

During the growing/rearing phase (9-20 weeks) results of the two trials showed that a grower mash of 12% protein was able to support pullet growth. In term of feed intake the birds that received 12% protein throughout the period still consumed the least feed and gained the least weight at the end of 20 weeks. Similar results had been reported by Douglas et al. (1973), Christmas et al. (1974) and Carlson and Nelson (1981).

Efficiency of feed utilization and cost per unit gain were also poor for these birds. From these two experiments, it is evident that protein restriction reduced the 20 weeks body weights of the birds as obtained in the works of Blair et al. (1970), Douglas and Harms (1976) and Carlson and Nelson (1981). This indicates that the small sized birds produced will require less feed for maintenance during lay and this is a form of saving to the farmer.

In the case of step-up protein regimen in trial 2, treatment 6 (12% protein 0-8 weeks; 16% protein 9-20 weeks) reduced the weights of the birds at 20 weeks. The other two treatments (7 and 8) produced weights comparable to that of the control treatment. This was contrary to the results of Leeson and Summers (1980, 1982); Doran et al. (1983); Bish et al. (1984), and Robinson et al. (1986). These workers observed a significant decrease in the weight of the birds at 20 weeks. The differences in results may be due to the types of strains used. These workers used white egg-type strain of pullets while brown egg strain of pullets was used in the trial reported herein. The results of Maurice et al. (1982) brown egg strain pullets were similar to the results of this trial, as they did not observe a significant reduction in weight gain.

A single-stage 16% crude protein diet was found to be comparable in effect to the control treatment in addition to the advantage of its simplicity. Leeson and Summers (1982) reared pullets on 14% protein and the birds were comparable in body weight to the control birds on higher protein level at 20 weeks. This performance was achieved with less protein intake during rearing. Savings could be made by rearing pullets on 16% protein diet from day old.

The effect of protein restriction on subsequent egg production did not have any significant effect on the parameters tested during the laying phase in trial 1. The birds that received 12% protein throughout the growing period performed poorly during lay but the performance was not significantly lower than those of other treatments (See Table 5). The lowest protein grower mash fed between 0 to 20 weeks reduced cost of pullet production, delayed sexual maturity and delayed production peak in agreement with some of the results of Christmas et al. (1974). In this experiment 12% CP diet did not increase egg size at 50% production as reported by Christmas et al. (1974), due probably to the type of strain of birds used. Heavy strains of birds as used for this study react more favourable to stress than light strains as reported by Mbugua and Cunningham (1983).

In trial 2, age at first egg, age at 5% production and feed consumed from hatch to 5% and 50% production showed significant treatment differences (P(0.05). Birds on 12% protein from hatch to 20 weeks still performed most poorly (See Table 9). Feeding birds 20% protein from 0 to 8 weeks and 12% protein from 9-20 weeks resulted in laying house performance that was comparable to the control birds fed 20 and 16% protein at the respective periods. This indicates that if birds are started on a high protein diet (20% C.P) for the first eight weeks, they will tolerate a much lower protein diet in the growing phase and indeed perform well subsequently in the laying house. This regimen therefore can reduce cost of bringing pullets to lay without affecting performance.

Step up protein regimen gave a laying house performance comparable to the control birds. This result is expected as the birds used the

period (9-20 weeks) of improved plane of nutrition to compensate for the inadequate nutrition of 0-8 weeks. From the results obtained during the growing phase (i.e. 0-20 weeks), this form of regimen is not recommended as the feed intake of the birds increased with the increase in the plane of nutrition making the cost of rearing the birds to point of lay more expensive. Although the aim of this study was to find ways of reducing the cost of production, this form of feed restriction though more expensive is recommended for replacement Pullets started off badly, as this will improve the birds to a level comparable to birds given a very good start. The laying house results indicate that pullets that are started off on poor feed can compensate and have production levels comparable to the control birds after two months in lay as indicated in the result of trial 2b (Table 9). It is interesting to note that even when birds were started on 12% CP diet (0-8 weeks) and later fed 16% CP diet (9-20weeks)as in treatment 6, they still perfonned as well as the control indicated in Table 10.

For the 16% single stage protein regimen, rearing treatment had no significant (P)0.05) effect on the mean production parameters measured in the 16 weeks laying period and this agrees with the findings of Leeson and Summers (1982).

The two trials on the effect on quantitative feed restriction on the growth of pullets showed that this form of restriction resulted in a significant (P<0.05) decrease in feed intake and weight gain. Similar results had been reported by Cumming (1972), Mbugua and Cunningham (1983) and Seller et al .(1984). The severity of restriction determines the lightness of the birds at the end of the restriction period. During the restriction period (9-20 weeks) the birds that were fed every other day were the lightest of the birds in trial 3a (Table 12) and those birds consumed the least feed.

Trial 4a (Table 15) showed a similar pattern. There was a direct relationship between the amount of feed consumed and the amount of weight gained. Quantitative feed restriction significantly (P<0.05) reduced the weight of the birds at sexual maturity (which is the aim of feed restriction) thereby lowering the cost of producing the pullets at point of lay. Consequently less feed will be required for maintenance during lay.

In terms of costs, there was no significant difference (P>0.05) in cost of feed per kilogramme weight gain. Birds that were fed every other day were costly to raise per kilogramme weight gain and they also required the least feed for body maintenance since they reached point of lay at a reduced weight.

During the laying period the type of rearing before laying did not significantly affect the laying performance of the birds. Abu-Serewa (1978) reported no significant differences in rate of lay, hen-housed production, average egg weight and final body weight and rate of mortality when birds were fed 5 days in a week. In the study reported herein a more severe method was used (feeding every other day) to obtain the same results. The advantages of quantitative feed restriction are in bringing the birds to lay at a lighter weight and at a lower cost while being able to obtain a production level comparable to the control birds reared at a higher price.

Feed restriction (quantitative or qualitative) should be introduced during the rearing replacement layers as this study clearly shows that restriction of feed during rearing does not affect subsequent egg production of the birds. Also the study shows clearly that in periods of scarce feed resources, growing pullets raised on not-so-good feed can compenstate for losses in performance without compromising eventual production if an adequate diet is fed in later life.

REFERENCES

Abusereiwa, S., 1978. Effect of restricting the feeding time of egg type pullets at different ages during rearing on body weights and subsequent laying performances. Australian Journal of Experimental Agriculture and Animal Husbandry 18: 70-74.

Association of Official Agricultural Chemists, 1965. Official Methods of Analysis of the A.O.A.C., 10th Edition Washington D.C.

Auckland, J.N., and R.B. Fulton, 1973. Effects of restricting the energy intake of laying hens. British Poultry Science 14: 579-588.

Auckland, J.N., and S.B. Wilson, 1975a. Effect of moderate energy restriction on light and medium hybrid laying hens. British Poultry Science 16: 23-29.

Auckland, J.N., and S.B.Wilson, 1975b. Restricting energy intake of laying hens. Effect of different patterns of restriction and rehabilitation. British Poultry Science 16: 31-35.

Balnave, D., 1973. A review of restricting feeding during growth of laying type pullets. World's Poultry Science Journal 29: 354-362.

Balnave, D., 1974. The effect of feeding low protein diets on pullets from hatch to point of lay, the quantitative restriction of food during the subsequent laying period. British Poultry Science 15: 395-403.

Balnave, D., D.J. Farrell, and R.B. Cumming, 1978. The minimum metabolizable energy requirement of laying hens. World's Poultry Science Journal 34: 149-154.

Bell, D.D., and R.E. Moreng, 1972. Intermittent feeding and lighting of matured Leghorn hens. Poultry Science 51: 1783 (Abstract).

Bish, C.L., W.L. Beane, P.L. Ruszler, and J.A. Cherry, 1984. Modified step-up protein feeding regimens for egg-type chickens. 1. Growth and production performance. Poultry Science 63: 2450-2457.

Blair, R., W. Bolton, and R.M. Jones, 1970. Egg production of light and medium hybrids given diets varying in protein levels during the rearing and laying stages. British Poultry Science 11: 249-258.

Bolton, W., R. Blair, and D.W. Knight, 1970. Egg production of light and medium hybrids given diets varying in energy levels during the chicks rearing and laying stages. British Poultry Science 11: 53-66.

Bullock, D.W., T.R. Morris, and S. Fox, 1963. Protein and energy restriction for replacement pullets. British Poultry Science 4: 227-237.

Carlson, C.W., and R.A. Nelson, 1981. Grower diets and their effects upon subsequent performance of layer type pullets. Poultry Science 60: 1272-1281.

Chaney, L.W., and H.L. Fuller, 1975. The relation of obesity to egg production in broiler breeders. Poultry Science 54: 200-208.

Christmas, R.B., C.R. Douglas, L.W. Kalch, and H.H. Harms, 1974. The effect of low protein pullet growing diets on performance of 12 strains of laying hens. Poultry Science 53: 1910. (Abstract).

Combs, G.F., B. Cattis, and C.S. Shaffner, 1961. Studies with laying hens. 2. Energy restriction. Poultry Science 40: 220-224.

Connor, J.K., K.M. Barran, and D.E. Fuelling, 1977. Controlled feeding of layers. 2. Restriction in time of access to feed of replacement pullets and laying hens. Australian Journal of Experimental Agriculture and Animal Husbandry 17: 588-597.

Cumming, R.B., 1972. Experiments on the restricted feeding of egg type stock. Proceedings of the 1972 Australian Poultry Science Convention. Auckland, Page 119.

Cunningham, D.L., 1984. A comparison of controlled feeding programmes for maximizing returns of white Leghorn layers. Poultry Science 63: 2352-2357.

Cunningham, D.L., and S.J. Polte 1984. Production and income performance of white Leghorn layers feed restricted at various stages of production. Poultry Science 63: 38-44.

Deaton, J.W., and J.H. Quisenberry, 1963. Effect of calorie restriction during the growing period on the performance of egg type replacement stock. Poultry Science 42: 608-613.

Doran, B.H., W.F. Krueger, and J.W. Bradley, 1983. Effect of step-down and step-up protein-energy feeding system on egg-type pullets growth and laying performance. Poultry Science 62: 255-262.

Douglas, C.R., R.H. Harms, 1976. The influence of protein level of the grower diet upon subsequent size. Poultry Science 55: 1593 (Abstract).

Douglas, C.R., H.R. Wilson and R.H. Harms 1973. Laying house performance of pullets grown on wire vs litter floors on 9 vs 14% protein diets. Poultry Science 52: 2023 (Abstract).

Douglas, C.R., H.R. Wilson, T.S. Powel, and R.H. Harms, 1977. Nutrient restriction after 21 weeks of age and its effect on performance of Leghorn pullets. Poultry Science 56: 506-511.

Fuller, H.L., and W.S. Dunnhoo, 1962. Restricted feeding of pullets 2. Effects of duration and time of restriction on three-year laying house performance. Poultry Science 41: 1308-1314.

Gerry, R.W., and F.V. Muir, 1977. Performance of red x rock sexed linked hens subjected to restricted feeding during laying period. Nutritional Abstracts and Reviews Series B.47: 350.

Gous, R. M., 1977. Uptake of certain amino acids in vitro in chicken previously subjected to 3 methods of dietary restriction. British Poultry Science 18: 511-515.

Gous, R.M., 1978. A comparison of 3 methods of feed restriction of laying type pullets on growth and laying performance. British Poultry Science 19: 441-448.

Gowe, R.S., A.S. Johnson, R.D. Crawford, J.H. Downs, A.T., Hills, W.F. Mountain, J.R. Pelletier, and J.H. Strain, 1960. Restricted versus full feeding dueing the growing period for egg production stock. British Poultry Science 1: 37-49.

Hakim, N.F.A., and F.M. Attia, 1975. Effects of feed restriction on laying house performance of the Fayoumi chicks. Nutritional Abstracts and Reviews Series B. 45: 1076.

Heywang, B.W., 1940. The effect of restricted food intake on egg weight egg production and body weight. Nutritional Abstracts and Reviews Series B. 10: 246.

Jackson, N., 1970. The effect of restricting the individual daily energy intake of caged layers on the efficiency of egg production. British Poultry Science 11: 93-102.

Jackson, N., H.R. Kirkpatrick, and R.B., Fulton, 1969. An experimental study of the utilization by the laying hens of dietary energy partially supplied as animal fat. British Poultry Science 10: 115-126.

Kari, R.R., J.H. Quisenberry, and J.W. Bradley, 1977. Egg quality and performance as influenced by restricted feeding of commercial cage layers. Poultry Science 56: 1914-1919.

Lee, K., 1983. Performance of white Leghorns as influenced by various methods of restricted feeding during the growing period. Poultry Science 62: 1455 (Abstract).

Lee, P.J.W., A.L. Gulliver, and T.S. Morris, 1971. Review article. Quantitative analysis of the literature considering the restricted feeding of growing pullets. British Poultry Science 12: 413-437.

Leeson, S., and J.D. Summers, 1979. Step-up protein for growing pullets. Poultry Science 58: 681-686.

Leeson, S., and J.D. Summers, 1980. Production and carcass characteristics of white Leghorn pullets fed conventional or step-up protein diets. Poultry Science 59: 1839-1851.

Leeson, S. and J.D. Summers. 1981. Effect of rearing diet on performance of early maturity pullets. Canadian Journal of Animal Science 61: 743-749.

Leeson, S.,and J.D. Summers, 1982. Use of single stage low protein diets for growing Leghorn pullets, Poultry Science 61: 1684-1691.

Lillie, R.J., and C.A.Denton,1967. Evaluation of dietary protein levels for white Leghorns in the grower and subsequent layer periods. Poultry Science 46: 1550-1557.

Mbugua, P.N., and D. L. Cunningham, 1983. Effects of feed restriction on production performance of replacement pullets. Poultry Science 62: 1169-1176.

McGinnis, J.,and N. Dornowat, 1967. Do laying hens need all the feed they consume? Feedstuffs,Minneapolis 39: 22.

Maurice, D.V., B.L. Hughes, J.E. Jones, and J.M. Wober, 1982. The effect of reverse protein and low protein feeding regimens in the rearing period on pullet growth, subsequent performance, and liver and abdominal fat at the end of lay. Poulstry Science 61: 2421-2429.

Meyer, G.B., C.F. Props, T. Leighton Jnr. , and H.P. Krey, 1977. The influence of nutrient restricton during the prebreeder period on subsequent reproductive performance of breeder turkeys. 1. Growth, feed consumption and egg production. Poultry Science 56: 1738-1739 (Abstract).

Moran, E.T., Jnr., P.R. Ferket, R.J. Etches, and J.R. Blackmnn, 1983. Influence of plane of nutrition during sexual development on subsequent reproductive performance of small white breeder toms. Poultry Science 62: 1093-1100.

Nair, R.K. R.S., and A. Ramakrishnan, 1978. Comparative study of different levels of feed restriction in replacement pullets. Indian Journal of Animal Science 48: 894-897.

Nesheim, M.C., R.E. Austic, L.E. Card, 1979. Poultry Production. 12th edition, pages 134-139. Published by Lee and Febiger, Philadelphia.

National Research Council, 1984. Nutrients requirements of poultry. 8th revised edition National Academy Press Washington D.C.

Olomu, J.M., and S.A. Offiong, 1978. Optimum stocking density for broiler chickens in the tropics. Paper presented at the 5th Annual Conference of the Nigerian Society for Animal Production, Ahmadu Bello University, Zaria.

Pearson, R.A., and K.M. Herron, 1980. Feeding standards during lay and reproductive performance of broiler breeders. British Poultry Science 21: 171-181.

Plavnik, I., S. Hurwitz and H. Barash, 1982. The effect of feed restriction on the growth, feed conversion and fattening of Pekin duck. Nutritional Abstracts and Reviews Series B. 53: 199.

Polin, D., and J.H., Wolford, 1971. Egg production by white Leghorn adult females restricted in feed intake by limiting their time or allotted amount to eat. Poultry Science 50: 1618 (Abstract).

Pym, R.A.E., and J.K. Dillon, 1974. Restricted food intake and reproductive performance of broiler breeder pullets. British Poultry Science 15: 245-259.

Robinson, F.W., W.L. Beane, C.L. Bish, P.L. Ruszler, and J.L. Baker, 1986. Modified step-up protein feeding regimes for egg type chickens 2. Protein level influence on growth and production performance. Poultry Science 63: 122-129.

Robinson, D. G., G. Horsnel, and P. McMahon, 1978. Restricted feeding of egg strain chickens during growing and throughout extended laying period. Australian Journal of Experimental Agriculture and Animal Husbandry 18: 658-666.

Schneider, A.J., B.B. Bohren, and V.L. Anderson, 1956. The effect of restricted feeding on several genetically controlled characters in the fowl. Nutritional Abstracts and Reviews Series B. 26: 248-249.

Scott, M.L., M.C. Nesheim, and R.J. Young, 1976. Nutrition of chicken 2nd edition, M.L. Scott and Associates Ithnca, N.Y. USA.

Sherwood, D.H., and T.T. Milby, 1961. Controlled feeding of laying chickens. Nutritional Abstracts and Reviews Series B. 31: 1440.

Snetsinger, D.C., R.A. Zimmerman, and D.E., Greene, 1973. Limited feeding of egg strain layers. Poultry Science 52: 2087 (Abstract).

Snetsinger, D.C., R.A. Zimmerman and D.E., Greene, 1974. Limited feeding of medium weight pullets and layers. Poultry Science 53: 1980 (Abstract).

Seller, M., Y. Eitan, and T. Broody, 1984. Effect of diet and early quantitative feed restriction on the minimum weight requirement for onset of sexual maturity in white rock broiler breeders. Poultry Science 63: 1255-1261.

Steel, R.G.A., and J.H. Torrie, 1960. Principles and Procedures of Statistics McGraw-Hill Book Company Inc. New York, Toronto and London.

Summers, J.D., 1975. Restricted feeding of layers. Canadian Poultry Review 99: 24-26.

Summers, J.D., and S. Leeson, 1978. Dietary selection of protein and energy by pullets and broilers. British Poultry Science 19: 425-430.

Summers, J.D., W.F. Pepper, S.J. Slinger, and J.D. McConachie, 1967. Feeding meat-type pullets and breeders. Poultry Science 46: 1158-1164.

Sykes, A.H., 1972. Egg Formation and Production. Edited by B.M. Freeman and P.E. Lake pages 187-196. British Poultry Science Limited, Edinburgh.

Tsvetanov, I., N. Bakaiso, M., Pugi, E. Gonzales, and E. Pere, 1978. Restricted feeding of growing broilers in Cuban conditions. 1. Effect of restricted feeding on growth and sexual maturity. Nutritional Abstracts and Reviews Series B. 48: 239.

Voitle, R.A., and R.H. Harms, 1974. Full feeding versus restricted feeding of broiler breeder hens during production. Poultry Science 53: 1644 (Abstract).

Voitle, R.A., H.R. Wilson, and R.H. Harms, 1974. Comparison of various methods of nutrient restriction for delaying sexual maturity in broiler breeder pullets. Nutrition Report International 9: 149-157.

Waldroup, P.W., B. L. Damron, and R.H. Harms, 1966. The effect of low protein high fibre grower diets on the performance of broiler pullets. Poultry Science 45: 393-402.

Walter, E.D., and J.R. Aitken, 1961. Performance of laying hens subjected to restricted feeding during rearing and laying periods. Nutritional Abstracts and Reviews Series B. 31: 1440-1441.

Watson, N., 1974. Ovarian activity of the broiler hen in relation to restricted rearing. Proceeding of the 1974 Australian Poultry Science Convention Hobart, Page 160.

Wilson, H.R., D.R. Ingram, and R.H. Harms, 1983. Restricted feeding of broiler breeders. Poultry Science 62: 1133-1141.

Wright, C.F., B.L. Damron, P.W. Waldroup, and R.H. Harms, 1969. The performance of laying hens fed normal and low protein diets between 8 and 18 weeks of age. Nutritional Abstracts and Reviews Series B. 39: 687.

APPENDICES

APPENDIX 1

ANALYSIS OF VARIANCE FOR FEED INTAKE, FEED EFFICIENCY, WEIGHT GAIN AND COST PER UNIT GAIN FOR 0-8 WEEKS, 9-20 WEEKS AND 0-20 WEEKS (TRIAL 1a).

Table 1: Analysis of variance for feed intake for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	5	13020.761	4.083**
Error	12	3188.980	
9-20 Weeks			
Treatment	5	191101.993	6.509***
Error	12	29360.923	
0-20 Weeks			
Treatment	5	288381.586	8.345***
Error	12	34555.702	

** denotes significant at 1% level (P(0.01)
*** denotes significant at 0.1% level (P(0.001)

Table 2: Analysis of variance: for feed efficiency for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	5	1.502	20.575***
Error	12	0.073	
9-20 Weeks			
Treatment	5	2.016	4.721**
Error	12	0.427	
0-20 Weeks			
Treatment	5	0.796	4.975**
Error	12	0.160	

** denotes significant at 1% level (P(0.01)
***denotes significant at 0.1% level (P(0.001)

Table 3: Analysis of variance for weight gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	5	7895.455	22.591***
Error	12	349.488	
9-20 Weeks			
Treatment	5	49984.371	5.473**
Error	12	9132.803	
0-20 Weeks			
Treatment	5	45729.829	6.218***
Error	12	7354.910	

** denotes significant at 1% level (P(0.01)
*** denotes significant at 0.1% level (P(0.001)

Table 4: Analysis of variance for cost per unit gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Means Squares	F Value
0-8 Weeks			
Treatment	5	0.214	9.304**
Error	12	0.023	
9-20 Weeks			
Treatment	5	0.333	2.413 NS
Error	12	0.138	
0-20 Weeks			
Treatment	5	0.584	4.787**
Error	12	0.122	

NS denotes not significantly different (P)0.05)
** denotes significant at 1% level (P(0.01)

APPENDIX 2

ANALYSIS OF VARIANCE FOR LAYING HOUSE PERFORMANCE IN TRIAL 1b.

Table 1: Analysis of variance for weight at 1st egg.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	0.010	0.294 NS
Error	12	0.034	

Table 2: Analysis of variance for age at 1st egg.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	35.122	0.492 NS
Error	12	71.333	

Table 3: Analysis of variance for age at 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	30.267	0.338 NS
Error	12	89.556	

NS denotes not significantly different (P)0.05).

Table 4: Analysis of variance for age at 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	29.522	0.681 NS
Error	12	43.333	

Table 5: Analysis of variance for age at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	19588.756	1.023 NS
Error	12	19139.389	

Table 6: Analysis of variance for % at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	25.045	0.876 NS
Error	12	28.587	

NS denotes not significantly different (P)0.05).

Table 7: Analysis of variance for feed consumption to 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	310.394	0.240 NS
Error	12	1294.613	

Table 8: Analysis of variance for feed consumption to 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	271.615	0.328 NS
Error	12	826.976	

Table 9: Analysis of variance for feed consumption to the end of experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	155.806	0.117 NS
Error	12	1336.671	

NS denotes not significantly different (P)0.05).

Table 10: Analysis of variance for weight of birds at the end of the experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	0.023	1.353 NS
Error	12	0.017	

Table 11: Analysis of variance for hen-day egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	45.804	0.899 NS
Error	12	50.950	

Table 12: Analysis of variance for hen-housed egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	5	53.196	1.102 NS
Error	12	48.261	

NS denotes not significantly different (P)0.05).

APPENDIX 3

ANALYSIS OF VARIANCE FOR FEED INTAKE, FEED EFFICIENCY, WEIGHT GAIN AND COST PER UNIT GAIN FOR 0-8 WEEKS, 9-20 WEEKS AND 0-20 WEEKS (TRIAL 2a).

Table 1: Analysis of variance for feed intake for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	7	18951.771	11.307***
Error	16	1676.114	
9-20 Weeks			
Treatment	7	194316.865	5.774***
Error	16	33635.815	
0-20 Weeks			
Treatment	7	192670.945	4.644**
Error	16	41486.444	

**denotes significant at 1% level (P(0.01)
***denotes significant at 0.1% level (P(0.001)

Table 2: Analysis of variance for feed efficiency for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Means Squares	F Value
0-8 Weeks			
Treatment	7	1.251	26.617***
Error	16	0.047	
9-20 Weeks			
Treatment	7	1.635	17.211***
Error	16	0.095	
0-20 Weeks			
Treatment	7	0.893	13.95***
Error	16	0.064	

***denotes significant at 0.1% level (P<0.001)

Table 3: Analysis of variance for weight gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	7	11742.365	17.842***
Error	16	658.127	
9-20 Weeks			
Treatment	7	28592.251	15.449***
Error	16	1850.795	
0-20 Weeks			
Treatment	7	32409.880	13.686***
Error	16	2368.122	

***denotes significant at 0.1% level (P(0.001)

Table 4: Analysis of variance for cost per unit gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	7	0.167	11.929***
Error	16	0.014	
9-20 Weeks			
Treatment	7	0.231	9.625***
Error	16	0.024	
0-20 Weeks			
Treatment	7	0.434	7.356***
Error	16	0.059	

***denotes significant at 0.1% level (P<0.001)

APPENDIX 4

ANALYSIS OF VARIANCE FOR LAYING HOUSE PERFORMANCE IN TRIAL 2b

Table 1: Analysis of variance for weight at 1st egg.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	0.075	0.987 NS
Error	16	0.076	

Table 2: Analysis of variance for age at 1st egg.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	69.429	3.180*
Error	16	21.833	

Table 3: Analysis of variance for age at 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	60.185	4.248*
Error	16	14.167	

NS denotes not significantly different (P)0.05)
* denotes significantly at 5% level (P(0.05)

Table 4: Analysis of variance for age at 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	51.405	2.138 NS
Error	16	24.042	

Table 5: Analysis of variance for age at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	253.143	1.536 NS
Error	16	164.833	

Table 6: Analysis of variance for % at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	38.296	1.067 NS
Error	16	35.883	

NS denotes not significantly different (P)0.05)

Table 7: Analysis of variance for feed consumption to 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	749.553	2.879*
Error	16	260.394	

Table 8: Analysis of variance for feed consumption to 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	617.17	2.663*
Error	16	231.735	

Table 9: Analysis of variance for feed consumption to the end of experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	616.628	1.310 NS
Error	16	470.818	

NS denotes not significantly different (P)0.05)
* denotes significant at 5% level (P(0.05)

Table 10: Analysis of variance for weight of birds at the end of the experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	0.015	0.319 NS
Error	16	0.047	

Table 11: Analysis of variance for hen-day egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	27.193	0.888 NS
Error	16	30.631	

Table 12: Analysis of variance for hen housed egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	7	33.500	1.245 NS
Error	16	26.899	

NS denotes not significantly different (P)0.05).

APPENDIX 5

ANALYSIS OF VARIANCE FOR FEED INTAKE, FEED EFFICIENCY, WEIGHT GAIN AND COST PER UNIT GAIN FOR 0-8 WEEKS, 9-20 WEEKS AND 0-20 WEEKS (TRIAL 3a).

Table 1: Analysis of variance for feed intake for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of Freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	3	2376.548	2.549 NS
Error	8	932.362	
9-20 Weeks			
Treatment	3	1199017.425	26.14***
Error	8	45865. 106	
0-20 Weeks			
Treatment	3	1289075.223	29.886***
Error	8	43133.577	

NS denotes not significantly different (P)0.05)
*** denotes significant at 0.1% level (P(0.001)

Table 2: Analysis of variance for feed efficiency for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	3	0.066	1.200 NS
Error	8	0.055	
9-20 Weeks			
Treatment	3	0.089	0.308 NS
Error	8	0.289	
0-20 Weeks			
Treatment	3	0.125	1.263 NS
Error	8	0.099	

NS denotes not significantly different (P)0.05).

Table 3: Analysis of variance for weight gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	3	470.773	1.426 NS
Error	8	330.232	
9-20 Weeks			
Treatment	3	30546.332	3.806*
Error	8	8026.150	
0-20 Weeks			
Treatment	3	28559.904	4.771*
Error	8	5985.818	

NS denotes not significantly different (P)0.05)
* denotes significant at 5% level (P(0.05)

Table 4: Analysis of variance for cost per unit gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	3	0.024	1.200 NS
Error	8	0.020	
9-20 Weeks			
Treatment	3	0.047	0.635 NS
Error	8	0.074	
0-20 Weeks			
Treatment	3	0.095	1.462 NS
Error	8	0.065	

NS denotes not significantly different (P)0.05).

APPENDIX 6

ANALYSIS OF VARIANCE FOR LAYING HOUSE PERFORMANCE IN TRIAL 3b.

Table 1: Analysis of variance for age at 1st egg.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	11.639	0.302 NS
Error	8	38.500	

Table 2: Analysis of variance for weight at 20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	28.560	4.771*
Error	8	5.986	

Table 3: Analysis of variance for age at 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	27.667	0.365 NS
Error	8	75.833	

NS denotes not significantly different (P)0.05)
* denotes significant at 5% level (P(0.05)

Table 4: Analysis of variance for age at 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	16.889	0.574 NS
Error	8	29.417	

Table 5: Analysis of variance for age at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	23.193	0.473 NS
Error	8	49.084	

Table 6: Analysis of variance for % at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	2.980	0.114 NS
Error	8	26.123	

NS denotes not significantly different (P)0.05).

Table 7: Analysis of variance for feed consumption to 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	338.078	0.308 NS
Error	8	1097.741	

Table 8: Analysis of variance for feed consumption to 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	760.087	0.792 NS
Error	8	960.203	

Table 9: Analysis of variance for feed consumption to end of experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	1521.089	0.521 NS
Error	8	2919.150	

NS denotes not significantly different (P)0.05).

Table 10: Analysis of variance for weight of birds at the end of the experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	0.027	5.4*
Error	8	0.005	

Table 11: Analysis of variance for hen-day egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	23.992	1.060 NS
Error	8	22.629	

Table 12: Analysis of variance for hen-housed egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	3	24.677	0.828 NS
Error	8	29.793	

NS denotes not significantly different (P)0.05)
* denotes significant at 5% level (P(0.05)

Table 1: Analysis of variance for feed intake for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	2	4329.574	2.510 NS
Error	6	1725.592	
9-20 Weeks			
Treatment	2	1010435.151	19.060***
Error	6	53012.640	
0-20 Weeks			
Treatment	2	896862.964	14.217***
Error	6	63085.561	

NS denotes not significantly different (P)0.05)

*** denotes significant at 0.1% level (P(0.001)

Table 2: - Analysis of variance for feed efficiency for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	2	0.029	1.00 NS
Error	6	0.029	
0-20 Weeks			
Treatment	2	0.603	5.154*
Error	6	0.117	
0-20 Weeks			
Treatment	2	0.059	1.55 NS
Error	6	0.038	

NS denotes not significantly different (P)0.05)
* denotes significant at 5% level (P(0.05)

Table 3: Analysis of variance for weight gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-8 Weeks			
Treatment	2	1270.810	1.641 NS
Error	6	774.502	
9-20 Weeks			
Treatment	2	66829.738	24.993***
Error	6	2673.960	
0-20 Weeks			
Treatment	2	54824.233	11.566***
Error	6	4740.174	

NS denotes not significantly different (P>0.05)
*** denotes significant at 0.1% level (P<0.001)

Table 4: Analysis of variance for cost per unit gain for 0-8 weeks, 9-20 weeks and 0-20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
0-3 Weeks			
Treatment	2	0.010	1.429 NS
Error	6	0.007	
9-20 Weeks			
Treatment	2	0.180	4.500 NS
Error	6	0.040	
0-20 Weeks			
Treatment	2	0.154	3.756 NS
Error	6	0.041	

NS denotes not significantly different (P>0.05)

APPENDIX 8

ANALYSIS OF VARIANCE FOR LAYING HOUSE PERFORMANCE IN . TRIAL 4b.

Table 1: Analysis of variance for age at 1st egg.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	36.778	0.997 NS
Error	6	36.889	

Table 2: Analysis of variance for weight at 20 weeks.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	0.055	11.536 ***
Error	6	0.047	

Table 3: Analysis of variance for age at 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	43.111	1.24 NS
Error	6	34.788	

NS denotes not significantly different (P)0.05)
* ** denotes significant at 1% level (P<0.01)

Table 4: Analysis of variance for age at 50% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	42.332	2.458 NS
Error	6	17.222	

Table 5: Analysis of variance for age at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	964.778	32.520***
Error	6	29.667	

Table 6: Analysis of variance for % at peak production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	42.707	1.244 NS
Error	6	34.337	

NS denotes not significantly different (P)0.05)
***denotes significantly different at 0.1% level (P(0.001)

Table 7: Analysis of variance for feed consumption to 5% production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	441.994	1.269 NS
Error	6	348.312	

Table 8: Analysis of variance for feed consumption to 50% production.

Source of Variation	Degree of Freedom	Mean Squares	F Value
Treatment	2	235.435	0.544 NS
Error	6	432.760	

Table 9: Analysis of variance for feed consumption to end of experiment (36 weeks)

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	89.915	0.497 NS
Error	6	180.997	

NS denotes not significantly different (P)0.05).

Table 10: Analysis of variance for weight of birds at end of the experiment (36 weeks).

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	0.020	22.496 **
Error	6	8.7189E-04	

Table 11: Analysis of variance for hen-day egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	9.369	0.182 NS
Error	6	51.565	

Table 12: Analysis of variance for hen-housed egg production.

Source of Variation	Degree of freedom	Mean Squares	F Value
Treatment	2	1.355	0.036 NS
Error	6	37.250	

NS denotes not significantly different (P)0.05)
***denotes significantly different at 0.1% level (P(0.001)