INFLUENCE OF LIMITING THE FEED INTAKE FOR DIFFERENT LEVELS & DURATIONS IN GROWING EGG-TYPE PULLETS UPON VARIOUS ECONOMIC TRAITS

THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PART FULFILMENT OF THE REQUIREMENTS FOR THE
AWARD OF THE DEGREE OF

MASTER OF SCIENCE

IN THE FACULTY OF VETERINARY SCIENCE
(POULTRY SCIENCE)

BY

D. NARAHARI, B.V.Sc.

DEPARTMENT OF POULTRY SCIENCE
COLLEGE OF VETERINARY SCIENCE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
RAJENDRANAGAR
HYDERABAD-500030

1974

CERTIFICATE

This is to certify that this thesis entitled "Influence of limiting the feed intake for different levels and durations in growing egg-type pullets upon various economic traits" submitted for the degree of M.Sc.in Veterinary Science in the Major Subject of Poultry Science of the Andhra Pradesh Agricultural University is a result of bonafide research work carried out by Mr.D.Narshari under my supervision and that the Thesis has not formed in whole or in part,the basis for the award of any Degree,Diploma,or other similar degree or distinction.

The assistance and help received during the course of these investigations have been fully acknowledged.

C. V. Reddy
(C.V.REDDY)
Major Advisor

PROFESSOR & UNIVERSITY HEAD
Department of Poultry Science,
Veterinary College (A:P:A:U)
R'Nagar, Hyderabad-30:

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to Dr. C.V. Reddy, Professor and Head, Department of Poultry Science for his expert planning, valuable guidance and constant encouragement during the study reported herein and for his valuable advice in the preparation of this thesis.

Heartfelt indebtedness is expressed to Dr. S.M. Siddiqui, Associate Professor, Department of Poultry Science for his constructive criticism and valuable suggestions in the preparation of this thesis.

The author would like to take this opportunity to thank Dr. G. Veera Raghavan, Professor and Head, Department of Animal Science for permitting the author to utilize the laboratory facilities and for his valuable guidance, especially in the analytical work.

Sincere gratitude is expressed to Dr. N.V. Ramana Rao, Poultry Specialist for his co-operation and immense help rendered during the course of these investigations.

Further, sincere thanks are expressed to Dr. G. Venkataratnam, Dean, Faculty of Veterinary Science and Dr. V.N. Pargaonker, Principal, College of Veterinary Science for the help and facilities provided to carryout this study.

The author is indebted to the Government of Tamil Nadu for granting the necessary leave, but for which it would not have been possible to prosecute the post-graduate studies programme.

The author is also immensely obliged to the Indian Council of Agricultural Research, for awarding the research fellowship and also for permitting the author to conduct this study utilizing the facilities under the Scheme on "Restricted Feeding of Growing Pullets".

Last but not the least, appreciation is expressed to all the staff members of the Departments of Poultry and Animal Sciences and to the colleagues for their ready help and co-operation.

C O N T E N T S

INTRODUCTION

It is well known that feed cost is the single major item of recurring expenditure in poultry industry and also appears to be the prime obstacle for rapid development of the industry. Since the production cost of poultry products is directly influenced by feed cost, a considerable interest in recent years has concentrated around various feeding systems which can bring about a decrease in recurring expenditure without affecting the production performance of the pullets. One such method is, rearing of replacement stock on a low plane of nutrition, popularly known as "Restricted Feeding Programme".

The value of restricted feeding programme in rearing replacement pullets on their subsequent laying house performance was explored by several investigators, who believed that the first noticeable effect of restricted feeding was on the growth rate of birds, followed by delayed sexual maturity. However, there is much less agreement as to the effect on subsequent laying house performance, because the experimental procedure adopted varies from one worker to other.

Restricted feeding programme was not originally developed spontaneously. In early thirties, English poultry men prefered to keep the birds on the hungry-side before the grains were fed. It was believed that the excessive mortality in many flocks might be due to ad libitum feeding of the birds which led to excessive obesity and inability to withstand high summer temperature. It was also believed by some workers that *ad libitum* feeding predisposed the birds to Fatty Liver Haemorrhagic Syndrome and Avian Leucosis Complex.

Thus restricted feeding programme came into vogue as a means to improve the laying house viability of birds, especially for the heavy meat-type breeder hens. Subsequently interest was developed to utilize this regimen to reduce the rearing cost of replacement pullets.

Several investigators have shown that the delayed sexual maturity was manifested by shortening of the time required to attain the peak production resulting in the maintenance of the peak for a longer period. They also showed that delayed onset of egg production resulted in a reduction in the number of small eggs at the begining of production; thereby increasing the number of settable eggs. Quite a number of researchers also reported better feed utilization in favour of restricted groups.

Many of these results seem to depend upon the age, length and severity of feed restriction. There is little evidence concerning the best method of restriction and also the age at which the restriction should be started or stopped for optimum perfomance.

Keeping this in view, the present investigation was undertaken to determine the ideal level and duration of feed restriction for optimum laying performance. An attempt was also made in this study to demonstrate whether limiting the feed intake of developing pullets had any effect upon the nitrogen retention and the metabolizability and metabolizable energy content of the diet.

REVIEW OF LITERATURE

Some of the well known methods of feed restriction programmes are: (1) Mechanical restriction of the feed i.e., limiting the total feed intake, (2) Nutrient restriction or feeding incomplete diets where levels of energy, protein, amino acids or any other nutrients are lowered, (3) Restricting the feed intake by diluting the diets with fibre, (4) Limiting the feeding time to certain number of hours in a day, (5) Withholding the feed for certain number of days in a week (ex: feeding on alternate days, skip-a-day programme etc.), (6) Using a grain and mash system, (7) Feeding unpalatable diets, (8) Limiting the photoperiod, (9) Controlled feeding based on calculations of actual needs and (10) A combination of two or more of the above methods at a time.

MECHANICAL RESTRICTION OF FEED

Sherwood and Milby (1954) and Milby and Sherwood (1956) restricted the feed intake of growing pullets from six weeks of age until start of production to 70 and 85 per cent of *ad libitum* fed birds on range and confinement methods respectively. They observed a delay of 15 to 26 days in sexual maturity. Feed cost to the date of first egg was greater for restricted birds in confinement. Eggs produced on the first day by all restricted birds were larger than those which were full-fed but on any given calender date, the eggs were of the same size. Egg production, feed utilization, fertility and hatchability were not affected by restricted feeding.

Isaacks *et al.* (1958) subjected broiler-breeder replacement pullets from 8-20 weeks of age to restricted feeding by limiting the amount of feed to 70 per cent of *ad libitum* or by use of high fibre diet. They reported that feed restriction delayed the onset of egg production by two weeks, reduced housing-time body weights but had little effect on egg size.

Fuller *et al.* (1959) limited the feed intake of Leghorn chickens to 9 lbs/100 birds/day during 6-12, 6-18, 6-24 or 12-24 weeks of age. Body weights were depressed depending upon the duration of restriction. In groups, where restriction was continued upto 24 weeks the onset of egg production was delayed by 5 weeks beyond the controls but attained equal body weight and egg production at 30 weeks of age. Egg mass was practically the same at 28 weeks of age. Restriction for shorter periods had no effect on egg production. Mortality was higher in restricted groups during growing period but the reverse was true in laying period. Similar results were also reported by Fuller and Dunahoo (1962).

In an extensive five-year study on this subject at various locations in Canada, Gowe *et al.* (1960 b) reported that limiting the feed intake of egg-type replacement stock both on range and in confinement, increased rearing mortality, decreased housing body weight, delayed sexual maturity, decreased laying house mortality and number of small eggs laid and increased rate of egg production. In addition, restricted feeding had beneficial carry over effect into the second laying year by way of rapid and short moulting period followed by higher rate of production. Gowe and Lemay (1961), in addition to these results noticed strain X treatment interaction for age at sexual maturity and body weight at housing time.

Berg and Bearse (1961) fed Leghorn growers either corn or barley rations; either full-fed or restricted to 83 per cent of full-fed and concluded that neither kind of grain nor feed restriction affected age at sexual maturity or rate of lay and mortality. Restricted feeding and barley rations reduced body weights. Egg size in restricted fed groups receiving corn rations was greater than others.

By restricting the feed intake of growing pullets to 70 or 60 per cent of ad libitum for varying durations, MacIntyre and Gardiner (1961) observed increased number of days to sexual maturity and a higher rate of egg production in restricted groups. Body weights of restricted groups were less at the time of housing but no differences were noticed afterwards. In all these cases there were direct relationships between duration of restriction and body weight at the end of restriction or delay in sexual maturity.

Restricted feeding of the basal diet to 10 lbs/100 birds/day, during 9-21 weeks of age significantly reduced body weights which never appeared comparable to the full-fed till the end of the experiment and was associated with increased rearing mortality with no significant effect on laying house performance (Deaton and Quisenberry, 1963).

MacIntyre and Gardiner (1964) fed Leghorn pullets to 70 per cent of ad libitum during various periods: 5-21, 5-23, 5-25, 5-27 and 5-29 weeks of age. Restricted fed birds were leaner throughout the experimental period. Sexual maturity as measured by days to 50 per cent production and time required to reach peak was delayed progressively as the duration of restriction was increased. All restricted groups reached a higher peak production than the full-fed groups. Restriction upto 25 weeks or lesser had a favourable effect on egg production; whereas restriction beyond 25 weeks of age appeared to adversely affect egg production. Feed efficiency was better with restricted groups except the group subjected to feed restriction to 29 weeks. Restricted feeding had reduced the number of small eggs but had no effect on mortality.

Strain et al. (1965) compared the performance of pullets subjected to either 20 or 30 per cent of feed restriction during growing period with those full-fed. They observed, an increased rearing mortality, reduced laying house mortality, delayed sexual maturity and reduced body weight at maturity.

Adams *et al.* (1967) restricted feed intake of pullets to 70 per cent of *ad libitum* during 20-24½ weeks of age and observed no differences in mortality and egg production. However, from 32 weeks of age, the restricted birds laid at a higher rate and the egg mass was also slightly higher.

Jones (1968) postulated that restriction would be more effective if begun at an early age of 5 weeks rather than 11 weeks of age. He reported higher egg production, better survival rate and feed efficiency for the early restricted groups.

Vaidya (1971) noticed reduced body weight gains, feed intake per unit gain and egg weight and increased egg production and age at first egg, when birds were given 80 or 70 per cent of the *ad libitum* fed control group. He also observed no differences in shank length and mortality due to feed restriction.

Han and Smyth, Jr. (1972) reported that the restriction of feed intake to 80, 70 and 60 per cent of *ad libitum* was accompanied by retarded growth rate. It also significantly delayed the time of development, as well as reduced the overall incidence of Marek's disease in 8-week old chickens following inoculation with JM virus at one day of age.

Reddy *et al.* (1974) restricted the feed intake of Leghorn pullets to 90, 80, 70 and 60 per cent of *ad libitum* fed groups from 7-20 weeks of age. They observed delayed sexual maturity and reduced housing body weights depending upon the severity of restriction. Egg production was not affected except in the severely restricted groups in which there was a drop in egg production. Restricted groups consumed more feed during laying period but overall feed efficiency was better in restricted fed groups. Egg size was larger for restricted groups. No differences were observed in the internal quality of the eggs.

NUTRIENT RESTRICTION

Sunde *et al.* (1954) compared complete and incomplete diets (without antibiotics and unidentified growth factors) and noticed delayed growth rate and sexual maturity with incomplete diets without lowering the subsequent performance.

Schneider *et al.* (1955) placed one group of New Hampshire and White Leghorn growers on fast growing and other groups on slow growing dietary treatments. During the laying period half of each group was given a conventional mash with a 17 per cent crude protein while the other half was fed a high-protein (21.5%) layer mash. They observed that the slow growing treatments retarded growth rate but the birds recouped after 4 weeks of full-feeding. Sexual maturity was delayed by 2 to 4 weeks with the slow growing dietary treatment. Rearing mortality was not affected by restriction but adult mortality was significantly reduced by dietary restriction. No consistent difference in egg size was observed after 32 weeks of age. Fast grown groups laid more eggs during the early part and the slow grown groups during the later part of egg production but no significant differences were observed in total number of eggs laid between treatments. Slow grown groups laid more number of settable eggs and their eggs had slightly higher fertility and hatchability. Laying rations had no significant effect on body weight, viability, egg size, egg number but normal protein ration was significantly superior in fertility and hatchability.

Denton and Lillie (1959) subjected Leghorn pullets to diets containing 12 and 16 per cent protein both during growing and laying periods. Birds fed low protein grower diets were lighter but had no effect on egg production or feed conversion. Whereas layer diets containing 16 per cent crude protein was superior to the 12 per cent crude protein diet, with regard to both egg production and feed conversion.

Fuller (1959) fed pullet chicks of 1-10 weeks of age either with high or low-efficiency rations. During growing period they were full-fed, semi-restricted or severely restricted. The low-efficiency diet caused a reduction in body weight at 10 weeks of age but by 20 weeks this difference had disappeared. Sexual maturity was delayed depending upon the severity of restriction. With high-efficiency starting diet, egg production was highest in the restricted groups followed by low-efficiency diet and the full-fed, during growing period.

Pepper _et al._ (1959) fed birds both on range and confinement either with high or low energy diets during starting and growing periods. The diets were fed _ad libitum_ upto 12 weeks and later the feed consumption was restricted to an equicaloric intake basis until 20 weeks. There was no difference in egg production, feed efficiency and egg quality between the treatments.

By comparing the _ad libitum_ feeding of the control diet, with full-feeding of 10 per cent crude protein and 15 per cent fibre diet, during 8-24 weeks of age, in meat-type pullets, Waldroup _et al._ (1966) observed reduced body weights, delayed sexual maturity with low-efficiency diets but no differences in the laying house performance.

Wright _et al._ (1968) compared 10 and 16 per cent protein diets fed _ad libitum_ during 8-18 weeks of age to egg-type pullets and noticed delayed sexual maturity, improved feed efficiency and egg production in birds fed low-protein grower diets.

Summers *et al.* (1969) subjected broiler breeder pullets to diets having different protein and energy levels both during starting and growing periods and noticed significantly lowered body weights at 8 weeks of age with low-protein diets, however, body weights at the housing time were consistently the same. No differences were observed in mortality and laying house performance.

Couch *et al.* (1970) fed broiler-breeder replacement pullets during 8-26 weeks of age with isonitrogenous diets containing different levels of lysine. They observed retarded growth rate, delayed sexual maturity and better egg production and feed efficiency with low-lysine diets but mortality, fertility and hatchability were unaffected.

Voitle *et al.* (1970) compared broiler-breeder pullets fed a conventional 16 per cent protein diet during growing period, with the pullets on skip-a-day programme, low-lysine or low-protein diets. Age to sexual maturity and egg production were increased, while body weights and feed consumption were reduced by restricted feeding. Mortality and egg weight were unaffected.

DILUTION OF FEED

Dilution of feed with fibre or low-energy ingredients appears to be uneconomical because they cause increased feed intake. However some workers had successfully achieved feed restriction by this method, by limiting the quantum of intake of diluted feed on par with that of control groups fed with normal energy diets.

Isaacks *et al.* (1958) employed 15 and 20 per cent fibre levels in diets containing 13 per cent protein fed *ad libitum*. The 15 and 20 per cent added fibre diets fed in pelleted form resulted in a 3 and 4 week delay in the onset of egg production respectively and increased the egg size for the first part of the laying year.

Isaacks *et al.* (1960) subjected fall-hatched broiler-type replacement stock on range, either to high or low-fibre pelleted diets, full-fed or restricted to 70 per cent of *ad libitum* and observed delayed sexual maturity by 6-22 days. Body weights at housing time were less in restricted groups but at 57 weeks of age no differences were observed. High-fibre diets increased feed consumption but had no effect on mortality.

Pepper *et al.* (1961) found that the inclusion of saw dust at 20 per cent levels in grower rations reduced the net nutrient intake by only 6 per cent which exerted no influence on age at sexual maturity or subsequent performance.

Deaton and Quisenberry (1963) observed no significant differences in body weight, age at sexual maturity and the laying house performance between birds full-fed with basal diets and high-fibre diets. It was noticed by these workers that the birds on high-fibre diets ate more feed.

LIMITING THE FEEDING TIME

Novikoff and Biely (1945) restricted the mash feeding of range-reared pullets to 5 continuous hours daily from day old to one year of age and observed somewhat lower rate of growth and egg production. No differences were noticed in the mortality between the full-fed and restricted groups.

Milby and Sherwood (1953) limited the feed intake of December-hatched meat-type pullets by limiting the feeding time to a definite number of hours daily and noticed that the restricted feeding programme retarded growth rate and delayed sexual maturity by about 2 weeks. There was no material difference in production, egg weight or mortality under both programmes, since the feed consumed to point of lay was virtually the same.

Schumaier and McGinnis (1969) reported that limiting the feeding time of heavy breed replacement pullets during their growing period was an effective method of controlling body weight gains during both growing and laying periods. Egg size was reduced but other production factors were unaffected by restricting the feeding time.

Tanabe and Tamaki (1969) allowed meat-type chickens an access to feed for 3, 6 or 12 hours per day during 4 to 24 weeks of age. With 3 hours feeding time body weights were 20 and 17 per cent less for males and females respectively than 12 hour fed controls. Feed consumption was upto 80 and 84 per cent of <u>ad libitum</u> for males and females respectively. Sexual maturity was delayed by limiting the feeding time to 3 hours per day. At 28 weeks of age 3 hour fed groups laid heaviest eggs.

Patel and McGinnis (1970) limited the feeding time of caged hens and noticed 10-15 per cent lesser feed intake without affecting egg production. But body weight and egg weight were reported to be smaller than controls.

Polin and Wolford (1972) kept Leghorn hens under 6 different feeding time schedules for 6 weeks duration. Hens under split schedule of two 2½-hour periods or one 4-hour period had significantly improved feed/egg ratios of 15 and 11 per cent on 20 and 23 per cent less feed, respectively as compared to *ad libitum* controls.

WITHHOLDING THE FEED FOR CERTAIN DAYS IN A WEEK

In a report published by Arbor Acres breeding farm in 1965, it was stated that pullets fed every other day were compared with those fed every day. But on the "off" days pullets were fed 2 lbs of oats/100 birds/day and noticed increased egg production and hatchability of both off-season and in-season flocks. This had resulted in more uniform sized pullets at the time of housing.

Yoshida and Hoshii (1969) in an experiment fed Leghorn chickens either to appetite or restricted the birds by giving feed every other day or every third, fourth or fifth day or by offering feed for 3 hours daily with diets containing different levels of energy and protein. When fed to appetite every day, growth rate was less on diets with high or low-energy than medium-energy. With high and medium-energy, the chickens maintained body weight with feeding every other day or third day, but those fed every fourth or fifth day did not survive longer than 13 days. Those chickens which were given low-energy diet on every third day also died. By limiting feeding time to 3 hours daily only birds fed every day survived and others died.

Yoshida et al. (1970) fed pullets on alternate days, throughout growing and laying periods and observed slower growth rate. Feed intake was 16 per cent less than controls and sexual maturity was delayed. There was little difference between groups in egg production, feed conversion, hatchability or viability.

GRAIN AND MASH SYSTEM

Davis and Watts (1955) compared the effect of mash-grain ratios of 70:30 with 30:70, in addition to restriction of total feed intake, during starting, growing or laying periods. Ration treatment during starting or laying periods significantly reduced egg production. Treatment during growing phase did not affect egg production, but delayed sexual maturity.

Taylor et al. (1957) studied the usefulness of 70:30 mash and grain feeding to pullets on range or in confinement from 12-21 weeks of age. They observed that birds on mash-grain system, required much feed than all mash groups. Rate of production was not affected by rearing methods or feeding programme.

Fuller (1962) fed range-reared pullets with about equal amounts of grain and mash during growing period and observed slight reduction in body weight, increased egg size, egg production and improved feed efficiency in the laying house in favour of grain-mash system.

OTHER METHODS OF FEED RESTRICTION AND COMBINATION OF DIFFERENT METHODS

Singsen *et al.* (1954) conducted series of experiments for 3 years with meat-type pullets on range, which were given one of the following treatments during growing period: *Ad libitum* feeding of high-efficiency and low-efficiency rations, high-efficiency ration to 80 per cent of *ad libitum* and 30 per cent of low-efficiency diet plus 70 per cent oats. The results indicated that the rations fed during the growing period had a marked effect on feed efficiency and body weight to 6 months of age, but no consistent effect was observed on subsequent egg production or mortality and only a slight effect on egg size.

Quisenberry *et al.* (1959) compared the performance of pullets raised on normal Vs. high fibre, full-fed Vs. 70 per cent of full-fed and noticed that feed restricted birds were lighter, but no consistent differences in egg size, egg production, feed efficiency or mortality were in evidence. In another experiment birds during 14-22 weeks of age were either full-fed with normal grower rations or restricted to 10 lbs/100 birds/day or full-feeding of 15 per cent fibre rations containing 12, 16 or 18 per cent protein. They were reared in floor pens, cages or range. It was noticed that caloric restriction was effective in delaying sexual maturity, reducing body weight and influenced egg size slightly but had no effect either on egg production or mortality. Both fall and spring-hatched chickens gave similar results.

Cooper and Barnett (1960) accomplished feed restriction in growing pullets (8-24 weeks) by using Vermiculite and noticed supressed body weight and delayed onset of egg production but egg production and egg size were unaffected.

Sherwood (1960) studied the effect of high and medium energy feeds, full-fed or restricted along with controlled lighting programme on fall-hatched, egg-type chicken. Energy levels had no effect on egg production, while limiting the light or feed, increased egg production significantly.

Luckham et al. (1963) studied the effect on Leghorn pullets subjected to one or combination of the following treatments: Full-feeding, 70 per cent of full-feeding, 40 per cent added fibre and skipping one or two days in a week. They concluded that all growing treatments resulted in somewhat reduction in body weight and adult mortality compared to controls. Delay in sexual maturity, closely paralleled the decreases in the body weight. Some growing treatments slightly improved egg production.

Quermer and Becker (1963) and Howes and Cottier (1965) subjected growing pullets to different feeding regimens such as: *Ad libitum* feeding of normal grower ration, 77 per cent of *ad libitum*, low-protein diet, high-fibre diet and fortified corn diet fed *ad libitum* and noticed significant reduction in body weight and delayed sexual maturity. Feed consumption during growing period varied depending upon the type of restriction adopted.

Lillie and Denton (1966) studied the effect of three feeding programmes in Leghorn grower pullets using diets diluted with fibre, restricted feed intake to different levels and low-protein diets. During the laying period, half of each group was fed either 12 or 16 per cent protein layer ration. They reported that feeding of high-fibre diets *ad libitum* increased feed consumption significantly without affecting other traits. Restricted feeding lowered feed consumption and body weights. Rearing mortality was higher in the severely restricted groups. Feeding low-protein grower diets reduced body weights. There were no significant differences in egg production, feed efficiency, egg weight, laying house mortality, fertility or hatchability on the basis of grower and layer treatments, except that the layers fed on low-protein diet were leaner than layers fed normal-protein diet.

Abbott and Couch (1971) subjected growing pullets to one of the following treatments during 7-20 weeks of age: *Ad libitum* feeding, 80 per cent of *ad libitum*, skip-a-day, low-protein and low-lysine diets. Low-lysine, low-protein and feed restricted groups gained less weight, had delayed sexual maturity and laid at a higher rate. Full-fed and skip-a-day groups laid small eggs and consumed more feed per dozen eggs.

Kirkland and Fuller (1971) fed growing pullets with high or low-energy diets. One group receiving each diet had drinking water available at all times while the other received on alternate days only. When water was withheld the pullets did not eat enough of low-energy diet and therefore consumed only about 70 per cent of energy of controls. Thus feeding a low-energy diet along with restricted water intake proved to be an effective method of caloric restriction. This restriction had resulted in delayed sexual maturity, reduction in body weight and carcass fat and had significantly more total settable and larger eggs. Mortality during growing period was not related to water restriction even during hot summer months.

Fuller *et al.* (1973) delayed the sexual maturity of broiler-breeder pullets (3-8 weeks) by adopting any one or combinations of the following methods: Restricting energy intake to 2/3 of the control, use of low-lysine and protein diets, declining day-length and skip-a-day programme. Delay in sexual maturity had consistently resulted in increased egg production, egg weight and number of settable eggs. Energy restriction and declining day-length acted additively on productivity. Low-lysine and protein diets neither delayed sexual maturity nor improved egg production appreciably.

Proudfoot and Lamoreux (1973) studied the effect of separate and combined effects of three rearing and two adult dietary treatments. The rearing feed treatment consisted of a comparison of full-feeding with a "skip-a-day" feeding programme and the feeding of a low-protein growing diet. After peak egg production the daily feeding time was restricted for one-half the population to limited feed consumption to approximately 90 per cent of that of full-fed controls. The "skip-a-day" feed treatment resulted in the most hatching eggs, fewer double-yolked eggs, increased egg size, improved feed conversion, reduced body weight and higher monetary returns. The restriction of feed for adults had no important beneficial effect on performance.

FEED RESTRICTION DURING LAYING PERIOD

Heywang (1940) restricted the feed intake of laying hens to either 87.5 or 75 per cent of control group and noticed significant drop in egg production, without affecting egg size.

Similar results were reported by Davis and Watts (1955) and Schumaier and McGinnis (1969). In contrast to these reports, Singsen *et al.* (1958) observed improved egg production on hen-housed basis when energy intake of hens were restricted to 78 per cent of *ad libitum* or *ad libitum* feeding of low-energy diet. Similarly, Sherwood (1959) observed equal egg production, mortality, egg size and hatchability in both full-fed and 90 per cent full-fed groups of meat-type hens. Feed efficiency was slightly better on controlled intake of feed.

Hollands and Gowe (1961) studied the effect of feeding egg-type hens to 70 per cent of *ad libitum* (during first year only) over 2 years of lay. Following forced moulting restricted birds came to production more quickly and laid at a higher rate throughout the second year of production.

Walter and Aitken (1961) reported the performance of laying hens, subjected to restricted feeding during growing and laying periods. Growing period restriction resulted in increased age at first egg followed by higher rate of egg production. Total feed consumption was decreased by restricted feeding. Restriction during laying period saved some feed but was offset by a drop in egg production. This was compensated by higher production during second year. Egg weight, rearing and laying house mortality and final body weights were practically the same.

Combs *et al.* (1961) and Donaldson and Millar (1962) pointed out that restricting the energy intake of meat-type hens resulted in lowered egg production, body weight and egg size but did not affect mortality.

Quisenberry and Bradly (1962) fed layers in cages with diets containing different protein levels *ad libitum* and noticed that egg production was lowest at low-protein (13%) levels. Egg size was directly related to protein content of the diet.

Sherwood *et al.* (1964) concluded that mild feed restriction of meat-type breeder hens increased the number of chicks hatched per hen-housed.

Slinger *et al.* (1964) started skip-feeding two weeks after peak production was reached. Continuous withholding of feed for 24-39 hours/week significantly reduced egg production, egg weight, feed intake and feed efficiency. Fertility and hatchability were unaffected by skip-feeding.

Iino *et al.* (1969) reared meat-type pullets from 10-49 weeks of age on diets having medium or low-energy values. Diets were fed to appetite throughout or feed was withheld every 7th day. Restricted feeding had little effect on weight gain and intake of feed in growing stocks or on egg production or hatchability during the laying stage. But body weights were less and sexual maturity was delayed by 10 days.

Restricted feeding of low-energy diets had a deleterious effect, especially on egg production.

Jackson and Brown (1969) carried two experiments with medium and light breed hens, which were given balanced diets supplying either high or medium energy to appetite or restricted to 85 grams per day. Restriction of energy reduced total egg weight, egg number and body weight.

Iino _et al_. (1970) fed meat-type pullets throughout growing and laying periods to appetite or withheld feed on alternate days, on every third day or fed two days out of three. They reported that feed restriction gave leaner but healthier pullets with better viability. Restricted birds consumed less feed per hatchable egg produced than those fed _ad libitum_.

Jackson (1970) studied the effect of restricting the individual energy intake of caged layers on their performance. He restricted both high and medium-energy diets. Maximum egg production was obtained from the birds fed the medium-energy diet _ad libitum_. Restricting high-energy diet caused a significant reduction in body weight and slight drop in egg production and total egg weight. Feed efficiency was better with restriction of the high-energy diets.

Polin and Wolford (1971) restricted feed intake of Leghorn hens by limiting the feeding time and observed that the feed intake, total egg weight and body weight were significantly less than the control group. Feed-to-egg ratio was generally improved by restricted feeding.

Gerry and Muir (1972) while restricting the feed intake of laying hens in cages to 90 per cent of full-fed or limiting the feeding time observed lowered body and egg weights and feed efficiency and a slight drop in egg production.

PHYSIOLOGICAL AND METABOLIC DIFFERENCES BETWEEN FULL-FED AND RESTRICTED-FED CHICKENS

Hill and Anderson (1955) observed that metabolizable energy was unaffected by level of feed intake from 30 to 100 per cent of ad libitum.

Biely and March (1959) reported that the incidence of Avian Leucosis Complex (A.L.C.) was lowest in those chickens raised on a low-plane of nutrition as compared with the birds on high-plane of nutrition for all the four strains studied.

Frank and Waibel (1960) subjected Leghorn hens in cages to five different levels of protein and two levels of energy and noticed that the hens fed with high-energy diets were fatter and showed higher serum cholesterol levels than hens on low-energy diet. Protein levels did not affect serum cholesterol levels.

Gowe *et al.* (1960 b and 1965) studied the physiological effects of restricted feeding and noticed that birds on restricted feeding had relatively larger adrenals, pituitaries and gizzards (per gram of body weight) and had lower heart rate and blood pressure.

Sibbald *et al.* (1960 a) reported that dilution of chick starter diet with either cellulose or kaolin did not affect the metabolizable energy content of the diet.

Combs *et al.* (1961) reported better utilization of energy and feed and low levels of serum cholesterol while restricting the energy intake of heavy-type layers. On the contrary, Donaldson and Millar (1961 and 1962) observed poorer utilization of protein, vitamins and minerals and better utilization of energy when energy intake of meat-type laying hens were restricted to 75 or 80 per cent of the controls. Whereas, Vaidya (1971) reported no differences in the utilization of energy, protein, calcium and phosphorus among restricted and full-fed groups.

Nichols and Balloun (1963) concluded that restricting the feeding time of heavy-breed male chickens to two hours a day did not affect either serum cholesterol or systolic blood pressure. But by restricting the feed intake to 70 per cent of *ad libitum*, the serum cholesterol concentration tended to be higher at 16 weeks of age.

Sanslone and Squibb (1963) were of the opinion that with a constant protein intake, calorie restriction had greater effect than calorie excess in depressing the nitrogen balance in the chicken. They also believed an apparent adaptive process to continued moderate calorie restriction in chicken.

Siegel and Wood (1964) reported that the data on digestive efficiency as influenced by restricted feeding time was inconclusive. However in broiler-type male chickens at seven weeks of age, digestive efficiency was better for restricted fed groups.

Rose and Balloun (1966) noticed elevated serum cholesterol levels and increased liver lipids by restriction of protein intake. Lowered caloric intake markedly decreased serum cholesterol levels and liver lipids.

Mahapatro _et al._ (1968) observed greater digestibility with restricted feeding system. The rate of passage of feed through the digestive tract showed a direct relationship to the quantity of feed consumed.

Leveille (1969) noticed significant depression in hepatic fatty acids and cholesterol synthesis following 24 hours fasting. After refeeding, fatty acid synthesis was three times more but cholesterol synthesis remained depressed until the third day of refeeding but later reached the normal levels. Liver weight and liver glycogen decreased markedly during fasting and increased rapidly after refeeding. Liver total lipids was not much influenced by starvation. Liver cholesterol content was increased during fasting and decreased upon refeeding.

Yoshida and Hoshii (1969) observed a significant linear relationship between intake of energy and growth rate and negative correlation between gain during recovery period and body weight at the end of restriction. Fat content of carcass was reduced by restriction of medium energy diets and increased when changed to full-feeding.

Reddy (1971) reported significantly higher amounts of total serum cholesterol levels in restricted groups than full-fed groups during restriction period. But during the subsequent laying period, no differences were recorded in the serum cholesterol levels (Reddy, 1972).

Wolford and Polin (1971 and 1972) restricted the feed intake of Leghorn hens by limiting the feeding time and noticed significantly lower amounts of liver lipids, liver wet weight, liver water, liver dry weight, abdominal fat and body weight. There was less incidence of fatty liver haemorrhagic syndrome (F.L.H.S.) in restricted fed birds.

Hewitt and Lewis (1972) observed a significant increase in total plasma amino acid levels and individual concentration of serine, proline and glycine following feed restriction. Efficient utilization of dietary protein and relatively low levels of amino acids in the plasma were fairly closely related.

ECONOMIC SIGNIFICANCE OF RESTRICTED FEEDING PROGRAMME

Isaacks *et al.* (1960) observed overall feed saving of 25 per cent during rearing period due to feed restriction. Contrary to this, Sherwood (1960), Bullock *et al.* (1963) and Deaton and Quisenberry (1963) reported that in practice, feeding "high-fibre diet" was uneconomical, because it led to increased feed consumption. Based on such contrasting reports, Ewing (1963) concluded that limiting the feed (high or medium-efficiency) intake of growing pullets resulted in 25 per cent overall feed saving, whereas restricting by adding 15 and 20 per cent fibre resulted in 39 and 49 per cent increase in feed consumption respectively.

Patric (1962) suggested feeding of a conventional mash plus light oats or 10-15 per cent fibre mash during growing period to produce excellent pullets at less cost than the full-fed all mash controls.

Gowe *et al.* (1960 a and 1965) in their experiments over five year period at various stations in Canada, concluded that the feed cost of rearing pullets to 21 weeks of age on the 70 per cent restricted feeding was 23 or 24 per cent less per pullet than full-feeding. On the 80 per cent restricted feeding, it was 17 per cent less. Feed cost in the laying house were 6-13 per cent higher for restricted groups but there was a reduction in overall feed cost. Egg income from the restricted programme was higher due to increased egg production, higher percentage of large and medium sized eggs and increased livability. The higher net returns under the restricted feeding programme was due to both higher income from eggs and lower feed costs. Similarly, Hollands and Gowe (1965) observed that the restricted feeding regimen resulted in increased egg prodution, improved feed efficiency and increased monetary returns over the full-fed group for both the first and second year of laying period. However, Proudfoot and Gowe (1967) were of the opinion, that feed restriction during rearing period failed to improve economic traits compared to full-feeding. Two of the four experiments provide evidence for the presence of strain X feed treatment and strain X light X feed treatment interactions for economic traits.

Vaidya (1971) and Reddy (1972) reported greater monetary returns by restricted feeding of growing pullets to 80 and 70 per cent of <u>ad libitum</u> than full-feeding.

MATERIALS AND METHODS

Two experiments were carried out at the Poultry Field Laboratory, College of Veterinary Science, Hyderabad. The first experiment of 55 weeks duration was conducted from December 22, 1972 to January 10, 1974 to determine the effect of limiting the feed intake at different levels for varying durations on the performance of growing commercial pullets. The second experiment was conducted from October 12 to December 3, 1973 (53 days) to explore whether restricted feeding had any influence upon nitrogen retention, metabolizability (metabolizable dry matter) and metabolizable energy content of the diet.

EXPERIMENT I

The experiment was planned as a 3 x 4 factorial design with three levels of feeding (100, 80 and 70%) with each level having four durations of restriction i.e., 5-10, 5-15, 5-20 and 5-25 weeks of age. Since ad libitum feeding (100% level) was to be used as a common factor against the different durations of restricted feeding programme, only one ad libitum feeding treatment served as the common control for all the four durations of restriction used. Consequently, a total of nine treatments only were employed instead of twelve. However, for the purpose of statistical analysis under the factorial design, the values of ad libitum group were repeated four times. The different treatment combinations are shown in Table 1.

Table 1. - Experimental plan showing the regimen of dietary restriction and the stocks used

Experiment I

Treatment No.	Treatment code	Feeding regimen adopted	Number of survivor birds: At start of study	At start of feed restriction	At housing time (23 wks of age)	At the end of study (55 wks)
1	100%	*Ad libitum* feeding throughout, 0-55 wks(control group)	28	28	28	28
2	80:10	80% of control group from 5 to 10 weeks of age only	28	28	23	22
3	70:10	70% of control group from 5 to 10 weeks of age only	28	27	22	20
4	80:15	80% of control group from 5 to 15 weeks of age only	28	27	26	24
5	70:15	70% of control group from 5 to 15 weeks of age only	28	28	28	27
6	80:20	80% of control group from 5 to 20 weeks of age only	28	28	28	27
7	70:20	70% of control group from 5 to 20 weeks of age only	28	27	27	25
8	80:25	80% of control group from 5 to 25 weeks of age only	28	27	22	22
9	70:25	70% of control group from 5 to 25 weeks of age only	28	27	26	23
		Total	252	247	230	218

Experiment II

Treatment No.	Treatment code	Feeding regimen adopted	Replication number	Number of chicks started	Number of chicks at the end
1	100%	*Ad libitum* feeding throughout, 0-53 days(control group)	1	15	15
			2	15	15
2	80%	80% of control group from 26 to 53 days of age only	1	15	15
			2	15	15
3	70%	70% of control group from 26 to 53 days of age only	1	15	15
			2	15	15
			Total	90	90

Two hundred and fifty two, one-day old, commercial egg-type pullet chicks (Hy-line), belonging to the same hatch were obtained from a local commercial franchise hatchery. On the same day, all the chicks were randomly divided into nine groups of 28 each, identified by wing bands and weighed individually. The usual managemental procedures and disease preventive measures were followed uniformly throughout the experimental period.

Each group of chicks was randomly alloted to a litter-floor pen in a well ventilated house, using hover-type electric brooders upto four weeks of age. Weekly, pen-wise feed consumption and individual body weight records were maintained upto 25 weeks and thereafter once in four weeks until the end of the experiment. Fresh drinking water was always at the disposal of the birds. Practical type starter mash (Table 2) was fed to appetite to all groups of chicks till the end of four weeks of age.

At the begining of fifth week, both brooding and use of artificial lights was stopped and chicks in each pen were randomly assigned to one of the dietary treatments as specified in Table 1. Care was exercised to avoid competition and overcrowding at feeding time.

Based on the chemical composition of the feed ingredients, (Ewing, 1963) the starter, grower and breeder diets used in

Table 2. - Ingredient composition of the experimental diets

Ingredients	Starter mash (0-8 wks) %	Grower mash (9-20 wks) %	Breeder mash (21-55 wks) %
Corn, yellow, ground	36.0	35.0	45.0
Rice, broken, coarse	10.0	20.0	10.0
Rice polishings	10.5	10.0	13.0
Wheat bran	9.0	10.0	6.0
Groundnut oil cake, ground	26.0	17.0	13.0
Fish meal	4.0	3.5	5.0
Meat meal, sterilized	2.5	2.5	-
Mindif[1]	2.0	2.0	4.0
Oyster shell meal	-	-	4.0
Total	100.0	100.0	100.0
Additives per 100 kg of the above diets:	(gm.)	(gm.)	(gm.)
Rovimix $A+B_2+D_3$[2]	25	25	30
Bifuran feed supplement[3]	50	50	-
Amprol 25%[4] (from 22nd wk. onwards)	-	-	50
Aurofac-2A[5]	500	500	250
Neftin-50[6]	-	-	100
Choline chloride (from 29th wk. onwards)	-	-	50

1. Mindif: Boots Pure Drug Company of India Private Ltd., contained 28% Ca, 5% P, 0.35% Fe, 23% NaCl, 100 P.P.M. Cu, 50 P.P.M. Co, 2000 P.P.M. Mn and 10 P.P.M. I.
2. Rovimix $A+B_2+D_3$: Roche Products Ltd., supplied 40,000 I.U. of Vit.A, 20 mgs of Vit.B_2 and 5,000 I.U. of Vit.D_3 per gm.
3. Bifuran:feed supplement: Smith Kline and French (India) Ltd. contained 25% W/W Nitrofurazone and 3.6% W/W Furazolidone.
4. Amprol 25%: Merk Sharp and Dhome (India) Ltd. Contained 250 gm. of Amprolium per kg.
5. Aurofac-2A: Cyanamid (India) Ltd. Contained 8 gm. of chlortetracycline per kg.
6. Neftin-50: Smith Kline and French (India) Ltd. Contained 50 gm. of Furazolidone per kg.

this experiment (Table 2) were formulated to satisfy the nutrient requirements as per I.S.I. (1968) recommendations. The diets were mixed after grinding the coarser ingredients in a hammer mill to pass through a 4 mm sieve. Later, samples of the mixed diets were assayed in duplicate for proximate principles by A.O.A.C. (1970) methods, after grinding the feed samples in a Thomas mill to pass through a 0.5 mm screen. Calcium and total phosphorous in the diets were estimated by the procedure described by Talapatra et al. (1940). The analysed chemical composition is reported in Table 3.

In accordance with the normal practice, coccidiostat was excluded from the breeder mash. However, it (Amprol-25%) was incorporated appropriately from 22nd week onwards, following an attack of coccidiosis and continued till the end of experiment. Choline chloride was also added to the breeder mash from the 29th week onwards till the end, subsequent to the observance of fatty liver haemorrhagic syndrome (F.L.H.S.) in the flock. These measures effectively controlled the pathological conditions.

During the restriction period the feed given to the restricted groups was based on the predicted feed intake of the control group. The weekly increase in feed intake (growth allowance) was determined from a regression equation based on the previous weeks feed consumption of the control

Table 3. - Analysed chemical composition of the diets (dry matter basis)

Nutrients	Starter mash %	Grower mash %	Breeder mash %
Total dry matter	90.82	93.24	94.15
Crude protein (N X 6.25)	20.85	17.20	14.73
Crude fibre	5.47	6.21	6.04
Crude fat	4.70	4.38	4.74
Nitrogen free extract	58.38	61.69	59.41
Total ash	10.60	10.52	15.08
Acid insoluble ash	2.79	3.88	3.75
Calcium	1.32	1.28	3.16
Total phosphorous	0.72	0.71	0.80
Metabolizable energy (K.Cal/kg.)*	2712.8	2722.3	2734.8
C/P ratio	130.1	158.3	185.1

* Calculated after Ewing (1963)

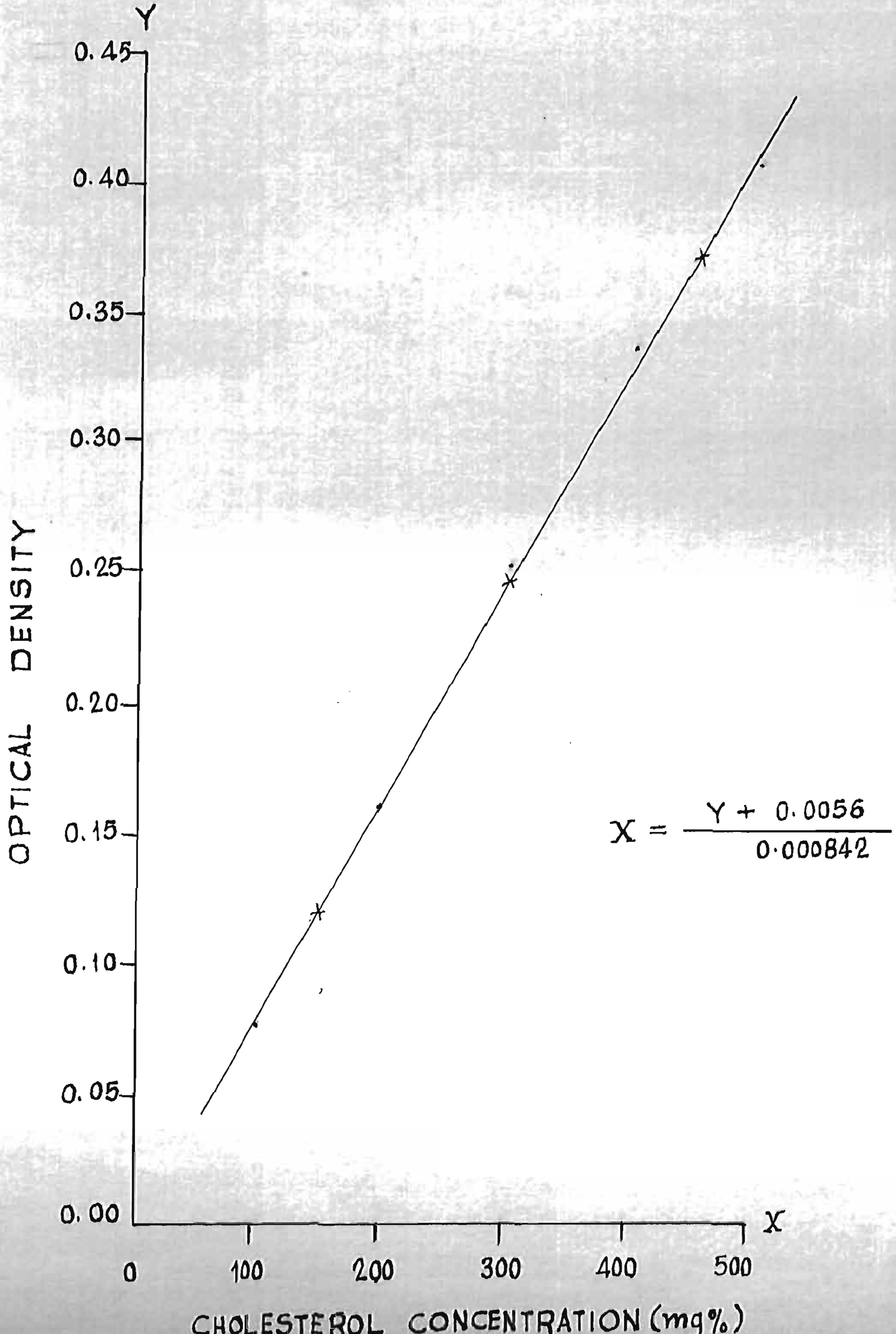
group. This growth allowance was added to the previous week's feed consumption by the control group, to represent the following week's feed consumption. 80 or 70 per cent of this predicted feed intake of ad libitum group was given to the concerned restricted groups. This amount was weighed at the begining of each week and kept in a separate feed drum for each group. Every morning and evening about 1/14th of this feed was fed to the concerned treatments so that a uniform rate of feeding was maintained throughout the restriction period. However, from 18th week onwards no growth allowance was added because the actual weekly increase in feed intake had come to a neglegible amount. So from 18th to 25th week onwards, only the allocated per cent of previous week's feed intake by the control group was given to the concerned restricted groups. At the end of the restriction period, the actual level of feed restriction achieved for each group was also worked out.

Post-mortem examinations were conducted upon all the birds that died during the experimental period and records of per cent mortality and cause of deaths were maintained accordingly.

Total serum cholesterol levels were determined during the 10th, 15th, 20th, 25th, 30th, 40th and 55th weeks of age from two randomly selected birds from each treatment. Serum was separated by centrifugation and the total cholesterol

FIGURE: 1

REFERENCE CURVE FOR "TOTAL SERUM CHOLESTEROL" ESTIMATION



levels were estimated by the method of Zlatkis et al. (1953) after preparing a standard reference curve (Figure 1).

From the day of first egg till the end of the experimental period, artificial light was provided in addition to natural day light, at a time increment of 30 minutes per week until a constant 16 hours day-length was attained. For each group the age (in days) at first egg, 10 and 50 per cent and peak production were determined. Feed consumption upto these stages was also recorded.

Laying house performance was studied for 8 x 28 day periods starting from 10 per cent production (162nd day) and the following data obtained:

a) Individual body weights at the end of each 28-day laying period.

b) Feed consumption and feed efficiency (kilograms of feed consumed per dozen eggs or per kilogram of eggs).

c) Net feed efficiency (N.F.E.), which refers to the units of feed consumed to produce unit weight of eggs and meat, was calculated using the formula:

$$N.F.E. = \frac{F}{EW+BW}$$

where, F = Feed consumed per pullet or by the whole group during the prescribed period

EW = Total weight of the eggs produced per pullet or by the whole group during that period.

BW = Weight gain or lost per pullet or by the whole group during that period.

In the present study, N.F.E. was calculated for each treatment (group) as a whole and for the whole experimental period (0-55 weeks), in order to reveal how best the feed consumed was utilized.

d) Performance efficiency index (P.E.I.) was calculated using the formula suggested by Morgan and Carlson (1968):

$$P.E.I. = \frac{30\ (EW)^2\ P}{BW.\ F}$$

where, EW = Average egg weight (gm)

P = Per cent hen-day egg production

BW = Average body weight (gm)

F = Average feed consumption per day (gm).

e) Per cent egg production (hen-day as well as hen-housed production).

f) Egg mass was studied by two different ways:

i) Egg mass on any given calender date was measured every day by weighing together all the eggs collected from each treatment. Since the weights of all the eggs produced were taken into account, the mean egg mass obtained from this data will represent the true population mean egg mass. Nevertheless for the purpose of statistical analysis, the mean mass of eggs collected during the last two days of each laying period was taken into account.

ii) Egg mass on certain days after first egg of the concerned treatment was obtained by individually weighing all the eggs laid on the 1st, 5th, 10th, 20th, 40th, 60th and 100th day of production by each group. However, for statistical analysis, a maximum of 10 observations per treatment was taken into account for each of the above days.

g) Per cent settability, fertility and hatchability were estimated during 2nd, 4th, 6th and 8th laying periods after introducing cocks into each pen at the start of the second period, with an approximate cock:hen ratio of 1:10. After collection of eggs for each hatch, the cocks were shuffled and interchanged from one pen to other, so as to avoid variations in fertility among the cocks. From each pen, as many settable eggs as possible were collected for each hatch, for 4 consecutive days, so as to avoid the intensity of selection of settable eggs. From this data per cent settable eggs for each treatment was calculated using the following formula:

$$\text{Per cent settable eggs} = \frac{\text{Total number of eggs fit for setting during thecollection period/group}}{\text{Total number of eggs produced during the collection period/ group.}} \times 100$$

Eggs collected each day for hatching were identified and held in cold storage (55^{o}F) until 4 hours before setting. Infertile eggs were removed on the 4th day of incubation, by candling. Per cent fertility among the settable eggs and hatchability of both the fertile eggs set and the total eggs produced during the collection period (chicks hatched per 100 eggs produced) were determined.

h) Relative (per cent) economy in feed utilization and feed intake per unit production was calculated for each treatment as a whole as shown in Table 23, based on the data on feed efficiencies expressed by different ways, in order to obtain a true estimate of the economic value. Relative economy in feed utilization is the per cent feed saved (or lost) per unit production in comparison to control group.

i) Income from eggs and spent hens, over feed cost was first determined for each group, based on the existing market rates for eggs, meat and feed. Later income over feed cost was calculated, i. per pullet started, ii. per pullet at the commencement of the feed restriction period and

iii. per pullet housed, by deviding the income per group with the appropriate number of survival birds at that time in each group as shown in Table 24. Moreover income over feed cost per survival pullet was also calculated based on the data on mean feed consumption from 0-55 weeks, per cent hen-day egg production from first egg to 55 weeks, population mean egg mass, mean final body weight and the existing market rates for eggs, meat and feed.

The data obtained under various traits were subjected to analysis of variance for a 3 x 4 factorial design (Snedecor and Cochran, 1968).

EXPERIMENT II

One hundred, one-day old, single comb White Leghorn, pullet chicks belonging to the same hatch were obtained from the Government Regional Poultry Farm, Saroornagar, Hyderabad. They were reared in electrically heated, thermostatically controlled, wire floor, battery brooders, kept in a well ventilated room. Light and fresh drinking water were provided on a continuous basis, throught the experimental period of 53 days. They were fed to appetite with practical-type, starter mash (Table 2) as in the first experiment, but the ingredients were ground to pass through a 2 mm screen, to avoid sorting of feed ingredients by the chicks; so that an uniform estimate of metabolizable energy could be obtained.

At the end of two weeks, the chicks were divided into different weight groups having a weight difference of 5 grams. The extreme weight groups were deleted, so that 90 chicks of medium weight were available for the metabolic trial. Chicks from each weight group were randomly picked in almost equal numbers to form 6 groups of 15 each, whose mean weight was almost uniform in order to reduce variation in the derived M.E. values.

The chicks were identified by wing bands and weighed individually. Thereafter, they were weighed at weekly intervals and finally at the end of the experiment. Weekly feed consumption records were maintained for all the groups, replication-wise.

Care was exercised in distributing replications in a random manner, so that no treatment appeared more than once in a verticle column of a 5-tier brooder and in the same horizontal tier of the two battery brooders that were used. Only the middle three tiers of the two batteries were selected, to house the chicks. This practice was adopted to reduce variation among replications and treatments due to tiers as suggested by Sibbald and Slinger (1963).

From 15th day onwards the chicks were continuously fed with the same starter mash (Table 2), but incorporated with

0.3 per cent of chromic oxide at the expense of equal quantity of wheat bran as recommended by Schurch et al. (1950) and Dansky and Hill (1952) in order to avoid total collection of excreta for determining the M.E. values. Sufficient care was exercised to avoid spilling of feed into the dropping trays by feeding small amounts 2-3 times daily.

From the 26th day onwards, the six groups of chicks were randomly assigned to the three different dietary treatments of restriction as scheduled in Table 1. The feed consumption in both the replications of the control group was measured daily. Based on the average feed consumption of the control group, 80 or 70 per cent of the feed was offered to the restricted groups on the next day. From the data on feed consumption and body weight gain, feed efficiency and the actual level of feed restriction achieved were calculated. No mortality was observed throughout the experimental period.

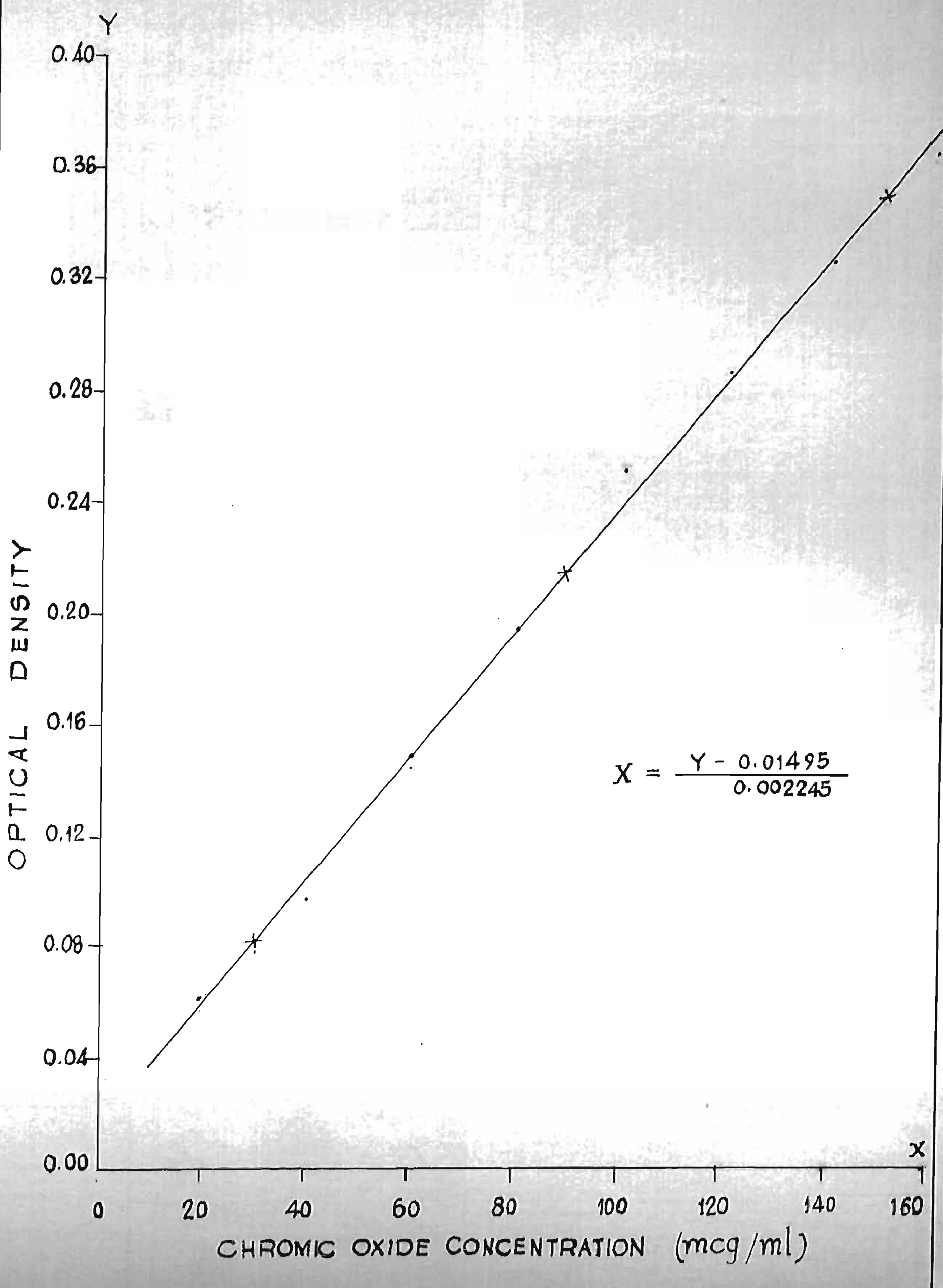
Metabolizable dry matter (M.D.M.) and metabolizable energy (M.E.) values of the feed and nitrogen retention (mg. of N_2 retained per gram of dry matter consumed) were estimated twice i.e., before and during restriction periods. Excreta samples were collected at 24-hour intervals on 22nd, 23rd, 24th and 25 day and again on 50th, 51st, 52nd and 53rd day of age. A day prior to each collection, dropping trays were thoroughly cleaned and polyethylene sheets were spread over the dropping trays. The next day a sample of about 100 grams of uncontaminated excrement from each replication were taken into a separate labelled, thick polyethylene bags, sealed air-tight and immediately stored in a freezer, until used for further analysis.

After four days of collection, all the four excreta samples of each replicate were pooled, homogenized and samples in duplicate were assayed for nitrogen by the Macro Kjeldhal method immediately to prevent loss of nitrogen. The moisture content of the samples was also determined simultaneously. Assay procedures as described in A.O.A.C., (1970) were employed in both the cases.

The remaining excreta samples from each replication were individually air-dried and ground to pass through a 0.5 mm screen. The ground samples were used for the assay of moisture (A.O.A.C., 1970), chromic oxide and gross energy. Chromic oxide content of the excreta samples was determined spectrophotometrically, using Bauch and Lomb "Spectronic-20", as described by Hill and Anderson (1958), after preparing a standard reference curve (Figure 2). Gross energy was estimated using Parr Oxygen, Non-adiabatic (Isothermal jacket) bomb calorimeter. Feed was also subjected to the same type of analysis.

FIGURE : 2

REFERENCE CURVE FOR "CHROMIC OXIDE" ESTIMATION



Based on the data obtained, nitrogen retention (mg. of nitrogen retained per gm. of dry feed consumed) was calculated using the formula suggested by Hill and Anderson (1958):

$$N_2 \text{ retention} = N_2/\text{gm. of dry diet} - \left[N_2/\text{gm. of dry excreta} \times \left(\frac{Cr_2O_3 / \text{gm. of dry diet}}{Cr_2O_3 / \text{gm. of dry excreta}} \right) \right]$$

Moreover, per cent metabolizability or metabolizable dry matter (M.D.M.) and metabolizable energy (M.E.) of the feed, as influenced by restricted feeding, were calculated as per the formulae given by Sibbald *et al.* (1960 b):

$$\text{M.D.M.\%} = \left[1 - \left(\frac{Cr_2O_3 / \text{gm. of dry feed}}{Cr_2O_3 / \text{gm. of dry excreta}} \right) \right] \times 100$$

$$\text{Classical M.E./gm. of dry feed} = \text{G.E./gm. of dry feed} - \left(\frac{Cr_2O_3 / \text{gm. of dry feed}}{Cr_2O_3 / \text{gm. of dry excreta}} \times \text{G.E./gm. of dry excreta} \right)$$

$$\text{Corrected M.E./gm. of dry feed} = \text{Classical M.E./gm. of dry feed} - \left[\text{Gross } N_2 / \text{gm. of dry feed} - \left(\frac{Cr_2O_3/\text{gm. of dry feed}}{Cr_2O_3/\text{gm. of dry excreta}} \times \text{Gross } N_2/\text{gm. of dry excreta} \right) \right] \times 8.22$$

Where G.E. = Gross Energy

The data on body weight gains during the restriction period (28-53 days) was subjected to analysis of variance (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

EXPERIMENT I

Body Weights:

The data on mean body weights of the pullets at various ages are shown in Table 4 and Figure 3. It may be seen that the mean body weights at the end of fourth week i.e., before the commencement of restricted feeding programme were approximately the same for all the groups of chicks. But at 10, 15, 20 and 25 weeks of age, there was a significant reduction ($P < 0.01$) in the body weights of the pullets which were fed upto 70 per cent of ad libitum in comparison to the control group, while they did not differ significantly from groups fed upto 80 per cent level, except at the time of housing. Feeding 80 per cent of ad libitum, depressed body weights significantly only at 23 and 25 weeks of age where restriction was prolonged from 5-25 weeks of age. Once the restricted feeding system was terminated, whether at 10, 15, 20, or 25 weeks of age, all such groups gained body weights at a faster rate with the re-introduction of full-feeding and had weights comparable to the control group. Similar results were obtained by Milby and Sherwood (1956), Fuller et al. (1959), Gowe et al. (1965) and MacIntyre and Gardiner (1961 and 1964).

Body weights of all groups of chickens at the time of housing (23 weeks of age) as well as at 25 weeks of age were

Table 4. - Mean body weights (gm.) at various ages as influenced by rearing period feed restriction

Treatment code	Age in weeks														Mean for levels*	Mean for durations*
	4	10	15	20	23*	25	27	31	35	39	43	47	51	55		
100%	159	639^{a}	906^{a}	1013^{a}	1182^{a}	1278^{a}	1270^{a}	1271	1336	1383	1436	1472	1561	1563	100%	5-10 wks
80:10	150	601^{ab}	901^{a}	1011^{a}	1145^{a}	1233^{ab}	1244^{a}	1307	1353	1463	1495	1493	1548	1578	1182^{a}	1158^{a}
70:10	160	552^{b}	862^{abc}	994^{a}	1147^{a}	1221^{ab}	1245^{a}	1281	1380	1420	1470	1520	1540	1568	80%	5-15 wks
80:15	160	597^{ab}	884^{ab}	996^{a}	1135^{ab}	1217^{ab}	1240^{a}	1281	1369	1452	1505	1502	1547	1628	1133^{b}	1161^{a}
70:15	155	562^{b}	820^{bcd}	980^{a}	1166^{a}	1242^{a}	1272^{a}	1309	1354	1435	1496	1531	1585	1629		
80:20	144	598^{ab}	872^{abc}	954^{a}	1167^{a}	1249^{a}	1272^{a}	1286	1342	1419	1487	1509	1532	1562	70%	5-20 wks
70:20	154	564^{b}	807^{cd}	886^{b}	1132^{ab}	1212^{ab}	1246^{a}	1270	1343	1437	1462	1453	1499	1543	1114^{b}	1160^{a}
80:25	147	601^{ab}	888^{a}	962^{a}	1084^{b}	1156^{bc}	1209^{ab}	1291	1374	1444	1488	1537	1576	1573		5-25 wks
70:25	154	552^{b}	782^{d}	846^{b}	1011^{c}	1087^{c}	1148^{b}	1213	1314	1351	1439	1452	1495	1503		1092^{b}
Mean for periods	154	585	858	960	1130	1211	1238	1278	1352	1423	1475	1497	1543	1572		

* Body weights at housing time (23 wks of age)

Means within a column, bearing atleast one same superscript do not differ significantly ($P \angle 0.01$)

Table 5. - Analysis of variance on body weights and weight gains

Sl. No.	Factor	Source of variation	D.F.	M.S.	F
1.	Body weights at 10 weeks	Due to treatments	8	23872.7	3.03**
		Error	238	7882.0	
		Total	246		
2.	Body weights at 15 weeks	Due to treatments	8	53465.1	6.01**
		Error	237	8891.2	
		Total	245		
3.	Body weights at 20 weeks	Due to treatments	8	89084.7	11.14**
		Error	237	7997.8	
		Total	245		
4.	Body weights at 23 weeks	Due to treatments	8	72618.0	11.57**
		Error	221	6275.1	
		Total	229		
5.	Body weights at 25 weeks	Due to treatments	8	83343.1	6.46**
		Error	221	12909.0	
		Total	229		
6.	Body weights at 27 weeks	Due to treatments	8	40727.5	3.71**
		Error	221	10983.2	
		Total	229		
7.	Body weights at 31 weeks	Due to treatments	8	20688.7	1.30
		Error	220	15964.3	
		Total	228		
8.	Body weight gains from 3rd to 8th period (32-55 wks)	Due to treatments	8	15231.6	1.25
		Error	209	12222.1	
		Total	217		
9.	Body weights at 23 weeks of age analysed on factorial design	Due to levels	2	132040.5	21.06**
		Due to durations	3	83270.5	13.28**
		Levels X Durations	6	37666.3	6.01**
		Error	302	6268.8	
		Total	313		

** Significant ($P < 0.01$)

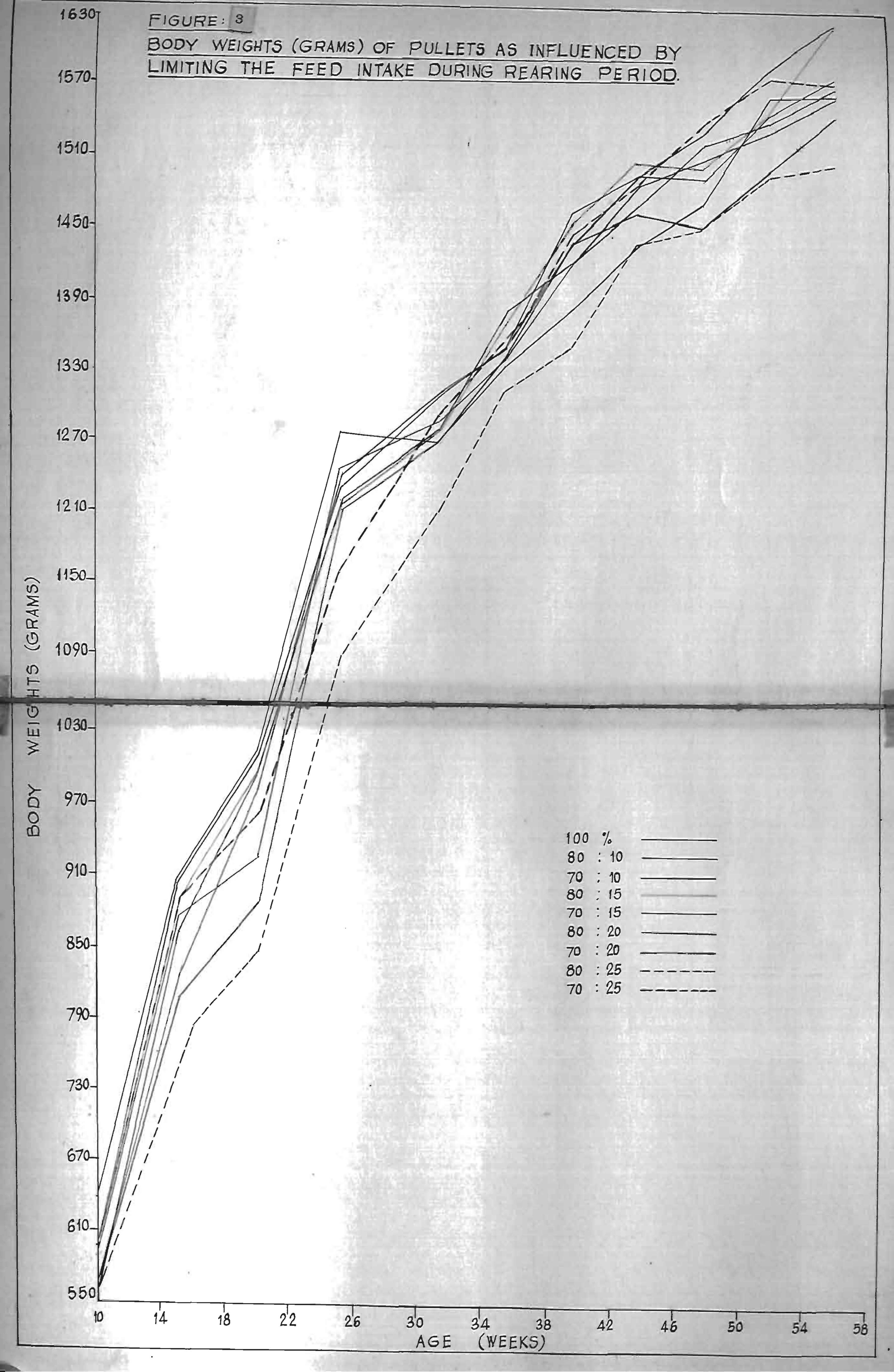


FIGURE: 3
BODY WEIGHTS (GRAMS) OF PULLETS AS INFLUENCED BY LIMITING THE FEED INTAKE DURING REARING PERIOD.
BODY WEIGHTS (GRAMS)
1630
1570
1510
1450
1390
1330
1270
1210
1150
1090
1030
970
910
850
790
730
670
610
550
10
14
18
22
26
30
34
38
42
46
50
54
58
AGE (WEEKS)
100 %
80 : 10
70 : 10
80 : 15
70 : 15
80 : 20
70 : 20
80 : 25
70 : 25

comparable, except for those groups, which were restricted for the longest duration (5-25 weeks), irrespective of the level of restriction. In these groups the body weights at these ages were significantly lesser ($P < 0.01$) than the control and many of the other groups having restriction for shorter duration, because these groups were under feed restriction upto 25 weeks of age. Mean housing body weights between these two groups (80:25 and 70:25) also differed significantly in proportion to the level of restriction. Gowe et al. (1960 b), Berg and Bearse (1961) and Reddy (1971) also noticed lesser body weights in restricted groups at housing time. There were significant differences in body weights at housing time both due to levels and durations of feed restriction and the both favouring control and milder restricted groups.

At 27 weeks of age, only the most severely restricted group (70:25) was significantly lighter than the control and most of the other restricted groups, but by 31st week even these differences in body weights had disappeared and remained more or less uniform till the end of the experiment for all the groups. On the other hand, Deaton and Quisenberry (1963), MacIntyre and Gardiner (1964) and Vaidya (1971) reported that the depressed growth rate in restricted groups continued till the end of the experiment.

Feed Intake And Efficiency:

Data on feed consumption are reported in Table 25. Although the experiment was planned to restrict the feed intake of birds theoretically upto 80 or 70 per cent of *ad libitum* group, the actual level of feeding achieved was slightly more than the desired levels as shown in Table 25. This was due to the fact that the actual feed consumption by the *ad libitum* group was less than the predicted amounts.

For about a week after lifting up of the feed restriction, the feed consumption in restricted groups, probably of a compensatory nature, was highest but thereafter it declined to become on par with that of the control group. Eventhen the cumulative feed consumption per bird upto 25 weeks was less in all restricted groups and this followed a linear pattern depending upon the severity of restriction. Similar results were obtained by Isaacks *et al.* (1960) and Gowe *et al.* (1965). However when the cumulative feed consumption was adjusted to the dates of sexual maturity of the respective groups there was no such linear drop in feed consumption among restricted groups depending upon the severity of restriction, because of the corresponding delay in sexual maturity. This observation is in agreement with the results obtained by Milby and Sherwood (1953 and 1956) and Fuller and Dunahoo (1962).

Table 6. - Mean feed efficiency (feed/gain) during rearing period as influenced by feed restriction

Treatment code	5-10 wks	11-15 wks	16-20 wks	21-25 wks	Mean for treatments
100%	3.18	7.01	16.30	9.72	9.05
80:10	2.85	6.64	15.45	10.94	8.97
70:10	2.87	6.15	13.50	11.42	8.49
80:15	2.94	5.41	15.91	11.10	8.84
70:15	2.77	5.26	12.31	10.23	7.64
80:20	2.81	5.66	16.80	9.18	8.61
70:20	2.75	5.58	16.18	7.99	8.13
80:25	2.83	5.41	15.73	10.57	8.64
70:25	2.83	5.90	15.97	7.49	8.05

Table 7. - Analysis of variance for rearing period feed efficiency

Source of Variation	D.F.	M.S.	F
Due to levels	2	4.04	0.13
Due to durations	3	0.24	0.01
Levels X Durations	6	0.18	0.01
Error	36	30.24	
Total	47		

Feed intake during the laying period or the overall feed consumption (0-55 wks) was variable and followed no particular trend. This observation is supported by the findings of Berg and Bearse (1961), Hollands and Gowe (1961), Walter and Aitken (1961) and Abbott and Couch (1971), while MacIntyre and Gardiner (1964) observed lowered feed intake during laying period by restricted groups. On the contrary, Gowe et al. (1965) and Reddy (1972) reported higher feed consumption among restricted groups during the laying period.

During growing period feed efficiency was slightly better in all restricted groups, when compared to full-fed group (Table 6), eventhough it was not statistically significant. The overall feed efficiency (Table 25) also showed a similar trend and the best feed efficiency was observed in the most severely restricted group (70:25). MacIntyre and Gardiner (1964), Reddy (1971) and Vaidya (1971) also obtained similar results.

During laying period the feed efficiency as measured by kilograms of feed consumed from first egg to 55 weeks of age per kilogram of eggs (Table 8) was better in all restricted groups than the *ad libitum* group. But feed efficiency, as measured by kilograms of feed consumed from 0 to 55 weeks of age per kilogram of eggs, was highest in the least restricted group (80:10) followed by control and other restricted groups.

Table 8. - Feed efficiency (feed/egg mass) for each treatment as a whole under different levels and durations of feed restriction during rearing period

Treatment code	Total feed intake upto the age at 1st egg[1] (gm.)	Total feed intake from 1st egg to 55 wks[2] (gm.)	Total feed intake from 0-55 wks (1+2) (gm.)	Total egg mass (gm.)	Feed (0-55 wks) / egg mass	Feed (1st egg to 55 wks) / egg mass
100%	169260	681270	850530	186475	4.56	3.65
80:10	165200	545980	711180	154097	4.62	3.54
70:10	156600	521900	678500	152506	4.45	3.42
80:15	149170	591590	740760	172620	4.29	3.43
70:15	155820	674930	830750	200207	4.15	3.37
80:20	164500	690490	854990	200430	4.27	3.45
70:20	156820	592190	749010	184325	4.06	3.21
80:25	149630	504040	653670	163686	3.99	3.08
70:25	174500	534350	708850	162396	4.36	3.29

The mean feed efficiency (for 1-8 periods) as measured by kilograms of feed consumed per dozen eggs (Table 9) was poorer for the groups which were restricted upto 25 weeks of age, than control or other restricted groups. This was due to very low egg production in these groups during the first laying period, since these groups were still under restricted feeding programme during this period. If the mean feed efficiency for either the last seven periods alone (2-8 periods) or the overall feed efficiency from first egg to 55 weeks of age (Table 25) was taken into account, it was in favour of all the restricted groups. Similar results in favour of restricted groups were reported by Fuller and Dunahoo (1962), MacIntyre and Gardiner (1964) and Abbott and Couch (1971). On the other hand, Reddy (1972) reported better feed efficiency in full-fed groups, followed in order by moderate and severely restricted groups. Nevertheless, Sherwood and Milby (1954) and Milby and Sherwood (1956) observed no differences in feed utilization.

Mean feed efficiency for the last seven laying periods was significantly better ($P \angle 0.01$) at 70 and 80 per cent levels of feeding than for full-fed group. Feed efficiency from first egg to 55 weeks of age also showed a similar trend. These results are in concurrence with those of MacIntyre and Gardiner (1964).

Table 9. - Feed efficiency (kgs. of feed consumed/dozen eggs) for each 28-day laying period as influenced by feed restriction during rearing period

Treatment code	First period	Second period	Third period	Fourth period	Fifth period	Sixth period	Seventh period	Eighth period	Mean for treatments (1-8 periods)	Mean for treatments (2-8 periods)	Mean for levels (2-8 periods)
100%	1.98	1.85	2.00	2.23	2.16	2.51	2.31	2.44	2.19	2.21	100%
80:10	2.14	1.81	2.07	1.91	2.05	2.40	2.15	2.34	2.11	2.10	2.21^a
70:10	2.00	1.77	1.99	1.71	2.10	2.03	2.07	2.36	2.00	2.00	80%
80:15	2.08	1.78	1.92	2.13	1.94	2.06	2.09	1.80	1.98	1.96	1.98^b
70:15	2.18	1.79	2.07	2.14	1.97	2.40	2.12	1.90	2.07	2.06	70%
80:20	2.34	1.93	2.09	2.29	2.02	2.12	2.02	2.04	2.11	2.07	2.00^b
70:20	2.87	1.99	2.18	1.66	1.93	2.19	1.99	1.93	2.09	1.98	
80:25	5.03	1.78	1.79	1.52	1.71	1.89	1.91	1.77	2.18	1.77	
70:25	17.16	2.00	2.15	1.96	1.87	1.92	1.88	2.02	3.87	1.97	

Means bearing atleast one same superscipt do not differ significantly ($P \angle 0.01$)

In general the overall feed efficiency (Table 25) was better in 80:25 group followed by 70:20 and other restricted groups. This indicates that the milder feed restriction for longer periods (80:25) or moderate feed restriction for shorter periods (70:20) seems to go well for achieving better feed efficiency.

Sexual Maturity:

The data on sexual maturity are reported in Table 10. Age at first egg and at 10, 50 and 75 per cent production was delayed by, −1 to 32 days, −8 to 27 days, −1 to 19 days and −2 to 16 days respectively in restricted groups in comparison to the control group. MacIntyre and Gardiner (1961) similarly showed that the number of days to reach 25, 50 per cent or maximal egg production was increased for restricted groups. It may also be seen from Table 10 that those groups, which laid their first egg earlier generally required a longer time to reach their peak production from the date of their first egg. Moreover the deviation in the age over the control group was lesser in restricted groups, at higher levels of production than at first egg.

No apparent differences were noticed in the ages to attain different stages of production between the control group and the groups restricted for shorter periods, probably

Table 10. - Age in days, at first egg and at different levels of egg production as influenced by dietary restriction during rearing period

Treatment code	Age at first egg	Age at 10% production	Age at 50% production	Age at peak production (75% or above*	Days to reach peak production from 1st egg(Col.5-2)
1	2	3	4	5	6
100%	147	157	170	179	32
80:10	148	156	172	178	30
70:10	149	158	169	177	28
80:15	146	149	173	182	36
70:15	151	165	169	177	26
80:20	157	168	171	178	21
70:20	163	166	178	185	22
80:25	159	169	186	191	32
70:25	179	184	189	195	16
Deviation in the age at sexual maturity, over the control group	-1 to 32 days	-8 to 27 days	-1 to 19 days	-2 to 16 days	

* Mean for three consecutive days

because the restriction was mild enough to exert no adverse effect on sexual maturity. Similarly, Berg and Bearse (1961) noticed no differences in sexual maturity between full-fed and mildly restricted groups.

Duration of feed restriction exerted much greater influence upon the age at sexual maturity when compared to the level of restriction, thereby indicating that longer periods of feed restriction were necessary to cause greater delays in sexual maturity. This finding derives support from the work of Fuller <u>et al.</u> (1969), MacIntyre and Gardiner (1961 and 1964) and Fuller and Dunahoo (1962), who also noticed that the sexual maturity was delayed progressively as the duration of restriction increased.

Egg Production:

Per cent hen-day egg production for the eight, 28-day periods are reported in Table 11 and Figure 4. The data on egg production were analysed both for 1-8 and 2-8 periods separately because some of the groups were under restricted feeding programme even during the first laying period (24-27 weeks) and consequently the egg production during this period was very low in such groups. The analysis for the former periods showed no significant differences due to feed restriction, whereas the analysis for 2-8 periods revealed

Table 11. - Effect of feed restriction during rearing period upon percent hen-day egg production

Treatment code	First period	Second period	Third period	Fourth period	Fifth period	Sixth period	Seventh period	Eighth period	Mean for treatments (1-8 periods)	Mean for treatments (2-8 periods)	Mean for levels (2-8 periods)
100%	56.12	73.10	65.56	52.17	60.84	48.98	56.76	52.30	58.23	58.53	100%
80:10	47.31	70.34	60.87	61.02	59.47	50.31	58.58	52.44	57.54	59.00	58.53[a]
70:10	53.70	73.90	65.26	67.18	65.39	64.11	64.11	53.39	63.43	64.83	80%
80:15	48.92	66.50	62.36	60.58	65.40	56.24	57.29	58.78	59.51	61.02	63.63[b]
70:15	54.50	77.04	60.33	63.01	66.20	50.52	61.77	62.57	61.99	63.06	70%
80:20	50.13	70.30	60.46	61.61	71.43	61.01	67.06	63.49	63.18	65.05	64.18[b]
70:20	34.92	63.73	56.37	68.43	71.71	60.14	66.14	68.86	61.16	64.91	
80:25	16.37	71.43	67.05	73.70	76.30	67.86	68.18	61.53	62.80	60.44	
70:25	5.10	59.80	60.85	56.28	65.71	67.01	70.03	67.86	56.57	63.93	
Mean for periods (3x4 treatments)	44.62[a]	70.43[c]	62.90[bc]	60.04[b]	65.46[bc]	56.01[b]	61.68[bc]	58.18[b]	59.93	62.11	

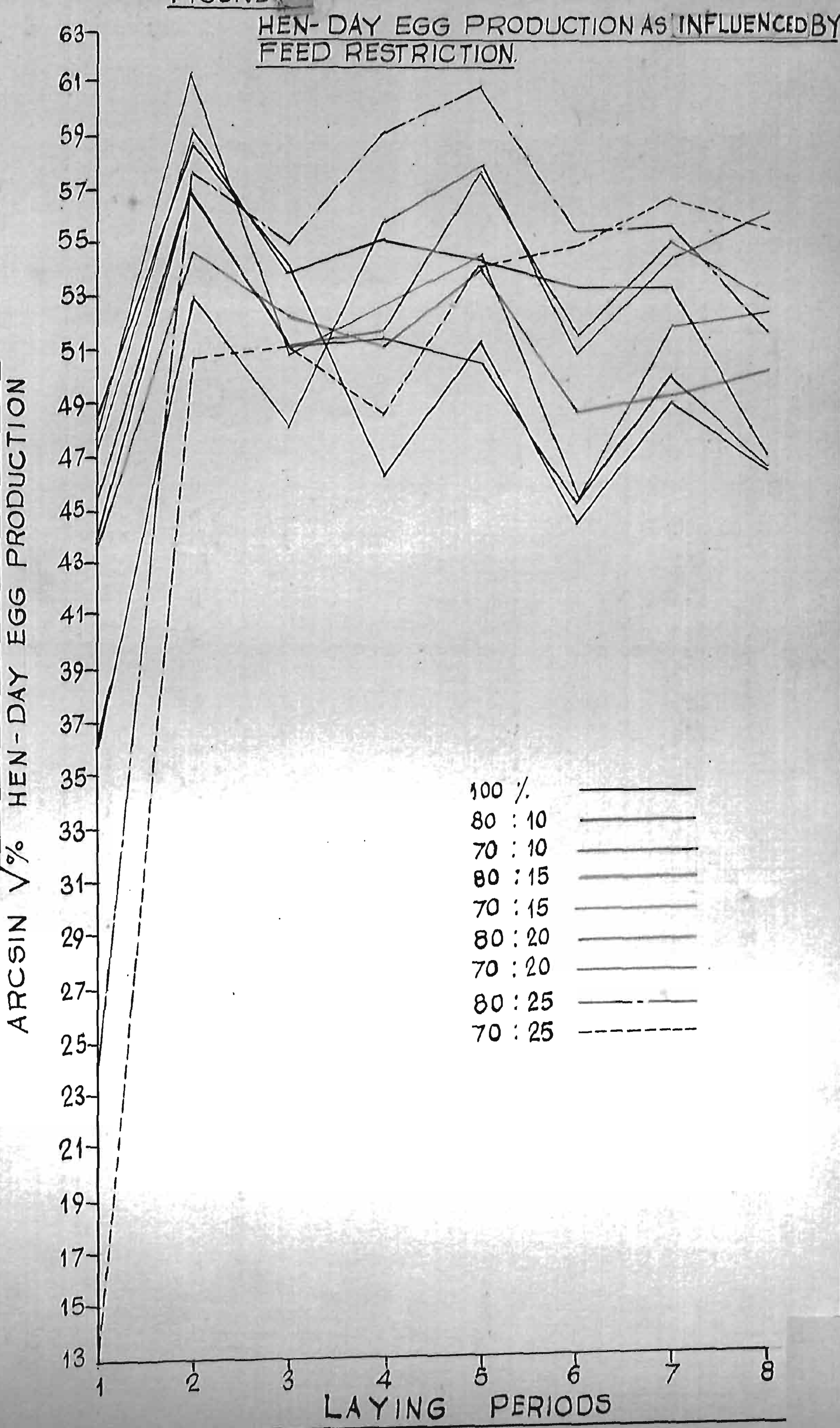
Means bearing atleast one same superscript do not differ significantly ($P < 0.01$)

Table 12. - Analysis of variance on feed efficiency during laying period and hen-day egg production

Sl. No.	Factor	Source of variation	D.F.	M.S.	F
1.	Feed efficiency (1-8 periods)	Due to levels	2	1.54	0.60
		Due to durations	3	2.48	0.97
		Levels X Durations	6	2.08	0.81
		Error	84	2.56	
		Total	95		
2.	Feed efficiency (2-8 periods)	Due to levels	2	0.48	12.00**
		Due to durations	3	0.06	1.50
		Levels X Durations	6	0.06	1.50
		Error	72	0.04	
		Total	83		
3.	Hen-day egg production (1-8 periods)	Due to levels	2	20.55	0.73
		Due to durations	3	6.09	0.22
		Levels X Durations	6	24.39	0.86
		Due to periods	7	261.18	9.26**
		Error	77	28.22	
		Total	95		
4.	Hen-day egg production (2-8 periods)	Due to levels	2	92.79	10.39**
		Due to durations	3	18.11	2.03
		Levels X Durations	6	18.84	2.11
		Due to periods	6	98.03	10.98**
		Error	66	8.93	
		Total	83		

** Significant ($P < 0.01$)

FIGURE: 4


HEN-DAY EGG PRODUCTION AS INFLUENCED BY FEED RESTRICTION.
ARCSIN √% HEN-DAY EGG PRODUCTION
63
61
59
57
55
53
51
49
47
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15
13
1
2
3
4
5
6
7
8
LAYING PERIODS
100 %
80 : 10
70 : 10
80 : 15
70 : 15
80 : 20
70 : 20
80 : 25
70 : 25

significant differences in egg production due to different levels of feed restriction. Although the mean egg production both for 1-8 and 2-8 periods were generally in favour of the restricted groups, the mean egg production for 2-8 periods appeared more favourable for the restricted groups. Similarly, when egg production (hen-day or hen-housed) was measured for each group, from its first egg to 65 weeks of age (Table 25), a notable difference in favour of the restricted groups was observed. This observation is in accordance with the results obtained by Fuller and Dunahoo (1962) and MacIntyre and Gardiner (1964).

It may be further seen from the data that the restricted groups came into production later and also laid at a lower rate than the control group during the early part ofthe laying period; but when once the influence of restricted feeding was overcome by subsequent _ad libitum_ feeding, restricted groups laid at a higher rate and also maintained the peak of lay, over a longer time. These results are supported by the observations of Gowe _et al._ (1960 b), Hollands and Gowe (1961), MacIntyre and Gardiner (1961), Walter and Aitken (1961), Quernor and Becker (1963) and Adams _et al._ (1967).

Levels of feeding had significantly ($P < 0.01$) better effect on egg production during the last 7 periods in favour of restricted groups. That is, lower levels of feeding(80 and

70% of *ad libitum*) resulted in significantly higher egg production than 100 per cent level of feeding. Egg production as measured from the date of first egg of the concerned treatment to 55 weeks of age also showed a similar trend. Reddy (1972) also observed significant differences in egg production due to various levels of feeding.

Significant differences ($P \angle 0.01$) were also observed for egg production during various periods. The lowest and the highest egg production was observed during the first and the second experimental periods respectively. The significantly low egg production observed with the longer restricted groups during the first period was due to late sexual maturity, since they were under restricted feeding programme even during this period. Highest egg production during the second period indicated that the pullets on restricted feeding took comparatively shorter time to reach the peak production.

Egg Weight:

Mean egg mass for various treatments on any given calender date (for 8 X 28-day laying periods) and on certain specific days after first egg of the concerned treatment are reported in Tables 13 and 14 respectively.

Statistical analysis of the data on egg mass on any given

Table 13. - Effect of rearing period feed restriction on mean egg mass (gm.) for each 28-day laying period (egg mass on any given calender date)

Treatment code	First period	Second period	Third period	Fourth period	Fifth period	Sixth period	Seventh period	Eighth period	Mean for treatments	Mean for levels
100%	43.5	45.7	47.7	50.9	53.1	53.6	56.5	57.6	51.1^{abc}	100%
80:10	42.9	46.5	48.3	51.8	53.5	54.2	57.4	58.7	51.7^{bcde}	51.1^{a}
70:10	41.9	45.7	47.3	51.5	52.6	54.6	57.1	58.2	51.1^{abc}	80%
80:15	41.8	46.0	48.1	51.0	52.3	53.4	55.6	57.0	50.7^{a}	51.3^{ab}
70:15	43.2	47.0	49.1	52.6	54.3	54.4	56.7	58.2	51.9^{cde}	70%
80:20	43.1	46.5	47.8	51.0	52.8	53.5	56.0	56.3	50.9^{ab}	51.7^{b}
70:20	44.0	47.3	49.3	52.7	54.3	54.9	57.3	58.5	52.3^{e}	
80:25	43.7	48.1	49.4	52.4	54.2	54.9	56.2	56.7	52.0^{de}	
70:25	45.8	47.7	49.0	50.8	51.7	53.1	56.0	56.8	51.4^{abcd}	
Mean for periods (3x4 treatments)	43.4^{a}	46.5^{b}	48.3^{c}	51.5^{d}	53.2^{e}	54.0^{f}	56.5^{g}	57.6^{h}	51.4	

Means bearing atleast one same superscript do not differ significantly ($P \angle 0.01$)

calender date (Table 15) revealed significant differences between treatments (levels X durations), but followed no definite trend. Significant differences were also observed between periods and also due to levels of feeding. The groups which were restricted to 70 per cent of the full-fed, produced significantly heavier eggs than the ad libitum fed group and those fed at 80 per cent level remained intermediate. Berg and Bearse (1961), Gowe et al. (1960 b), MacIntyre and Gardiner (1964), Adams et al. (1967), Reddy (1972) and Fuller et al. (1973) also observed larger mean egg size in restricted groups while Milby and Sherwood (1953 and 1956) and Fuller et al. (1959), observed no differences in egg size between full-fed and restricted groups. On the other hand Schmaier and McGinnis (1969) and Vaidya (1971), noticed reduced egg size in feed restricted groups.

When egg weight was measured on certain specific days after sexual maturity of the concerned group, such as 1st, 5th, 10th day etc., significant differences were observed due to levels and durations of restriction and also between treatments (L X D). 70 per cent of ad libitum feeding resulted in significantly superior egg weight than 100 or 80 per cent levels of feeding. Similarly, restriction for the longest duration (5-25 wks) also resulted in heavier eggs than those restricted for shorter periods.

Table 14. - Influence of feed restriction during rearing period on average egg weight (gm.) on certain days after first egg of the concerned treatment

Treatment code	1st day	5th day	10th day	20th day	40th day	60th day	100th day	Mean for treatments	Mean for levels	Mean for durations (3x4 treatments)
100%	29.0	40.0	38.4^{ab}	40.4	45.5	47.7	48.5	41.4^{a}	100%: 41.4^{a}	5-10 wks: 42.0^{a}
80:10	35.0	40.0	42.0^{bc}	38.2	47.1	47.2	51.1	42.9^{ab}		
70:10	33.0	39.0	38.3^{ab}	40.0	44.9	46.9	49.7	41.7^{a}	80%: 42.3^{a}	5-15 wks: 41.7^{a}
80:15	34.8	39.0	37.9^{a}	38.9	42.8	46.8	48.9	41.3^{a}		
70:15	33.0	36.8	38.8^{abc}	41.9	46.1	48.5	51.7	42.4^{ab}	70%: 44.1^{b}	5-20 wks: 42.7^{ab}
80:20	31.0	36.0	41.5^{abc}	41.1	45.7	46.7	52.2	42.0^{a}		
70:20	37.0	41.3	42.4^{c}	44.4	47.6	47.7	53.2	44.8^{bc}		5-25 wks: 43.8^{b}
80:25	31.0	39.0	38.8^{abc}	42.4	46.8	48.2	53.4	42.8^{ab}		
70:25	44.0	46.0	47.1^{d}	44.4	48.9	48.5	52.2	47.3^{c}		

Means bearing atleast one same superscript within a column do not differ significantly

Table 15. - Analysis of variance on egg weight

Sl. No.	Factor	Source of variation	D.F.	M.S.	F
1.	Egg mass on any given calender date (8x28-day periods)	Due to levels	2	2.97	7.49**
		Due to durations	3	0.30	0.76
		Levels X Durations	6	2.54	6.41**
		Due to periods	7	296.00	747.00**
		Error	173	0.40	
		Total	191		
2.	Egg mass at various days after first egg of the concerned treatment	Due to levels	2	242.50	8.74**
		Due to durations	3	167.90	6.05**
		Levels X Durations	6	154.50	5.93**
		Error	534	27.73	
		Total	545		
3.	Egg mass on 10th day after first egg of the concerned treatment	Due to levels	2	73.26	7.70**
		Due to durations	3	51.53	5.42**
		Levels X Durations	6	25.32	2.66*
		Error	45	9.51	
		Total	56		
4.	Egg mass on 40th day after first egg of the concerned treatment	Due to levels	2	36.95	2.76
		Due to durations	3	44.57	3.33*
		Levels X Durations	6	23.28	1.74
		Error	108	13.40	
		Total	119		
5.	Egg mass on 100th day after first egg of the concerned treatment	Due to levels	2	188.75	16.60**
		Due to durations	3	28.70	2.52
		Levels X Durations	6	16.53	1.45
		Error	107	11.37	
		Total	118		

* Significant ($P \angle 0.05$)

** Significant ($P \angle 0.01$)

largest egg size was obtained with 70:25 group, followed by 70:20 group and others. The mean egg weights of these two groups were significantly heavier than the control and some other restricted groups.

Analysis of the eggs laid on the 10th day after first egg, of the respective groups revealed significant differences between levels, durations and levels X durations, in favour of restricted groups. But eggs produced on the 40th and 100th day after first egg, differed significantly only for durations and levels, respectively. On similar grounds Sherwood and Milby (1954), Isaacks et al. (1958) and Fuller and Dunahoo (1962) reported that the eggs produced for first few days by restricted groups were larger than full-fed groups. The eggs produced for the first few days by the longer restricted groups were larger than full-fed or those of the shorter restricted groups, because the comparison was made between the size of the eggs laid by hens of different ages. That is why the egg weight increased with advancement of age and differed significantly from period to period (8 X 28-day laying periods). This clearly shows that the egg size primarily depends upon the age of the hen, regardless of the dietary treatments. This was in accordance with the findings of Davis and Watts (1956).

Performance Efficiency Index (PEI):

The data on PEI are reported in Table 16. Statistical analysis of the data for 1-8 periods (Table 19) revealed no significant differences between treatments as reported earlier by Reddy (1972).

Since the longest restricted groups were still under restricted feeding programme during the first laying period, the production was very low in such groups so analysis of variance was also worked out for the 2-8 periods only (Table 19) which revealed significant differences between levels, durations and levels X durations (treatment combinations). Lower levels of feeding (80 and 70%) and the longest duration of restriction (5-25 wks) resulted in significantly better PEI than the control group and those restricted for shorter periods. The low PEI for the control group may be due to relatively lower egg production, reduced egg weight and poor feed efficiency, observed with this group.

Fertility And Hatchability:

The effect of feed restriction during the rearing period, on per cent settable eggs, fertility among the settable eggs and hatchability of both the fertile eggs set and the eggs produced during the collection period are reported in Table 17. Control group and 80:20 group had comparatively lower percentage

Table 16. - Influence of feed restriction during rearing period upon performance efficiency index

Treatment code	First period	Second period	Third period	Fourth period	Fifth period	Sixth period	Seventh period	Eighth period	Mean for treatments (1-8 periods)	Mean for treatments (2-8 periods)	Mean for levels (2-8 periods)	Mean for durations (2-8 periods)
100%	27.1	31.0	30.7	30.3	32.8	28.0	31.9	31.3	30.5	31.0^{a}	100%	5-10 wks
80:10	24.8	32.9	30.0	28.8	33.6	29.6	35.6	33.6	31.1	32.0^{ab}	31.0^{a}	32.0^{a}
70:10	25.6	33.2	29.3	32.7	32.3	34.8	36.8	32.9	32.2	33.1^{abc}	80%	5-15 wks
80:15	24.3	33.4	31.8	30.2	33.7	33.1	34.3	40.1	32.6	33.8^{abc}	34.2^{b}	32.8^{a}
70:15	24.1	33.8	20.9	32.4	36.1	28.9	34.4	39.5	32.5	33.7^{abc}	70%	5-20 wks
80:20	22.6	31.4	29.3	28.8	33.4	32.2	36.6	35.9	31.3	32.5^{ab}	34.3^{b}	33.0^{a}
70:20	19.6	31.8	29.9	35.0	37.6	34.1	39.6	41.5	33.6	35.6^{cd}		5-25 wks
80:25	11.2	36.2	35.7	37.5	41.5	37.4	37.8	43.6	35.1	38.5^{d}		34.8^{b}
70:25	3.7	33.8	30.5	29.2	35.7	36.3	40.1	38.2	30.9	34.8^{bc}		

Means bearing atleast one same superscript within a column do not differ significantly

Table 17. - Effect of restricted feeding on per cent settability, fertility and hatchability

Treatment code	Settability	Fertility among settable eggs					Hatchability, on fertile eggs set						Hatchability on total eggs produced*
		1st hatch	2nd hatch	3rd hatch	4th hatch	Mean for treatments	1st hatch	2nd hatch	3rd hatch	4th hatch	Mean for treatments	Mean for levels	
100%	72.8	100.0	100.0	97.7	95.7	98.4	71.7	95.2	88.1	81.8	84.2	100%	60.3
80:10	79.0	100.0	100.0	97.7	100.0	99.4	70.3	82.5	65.1	89.6	76.9	84.2[a]	60.4
70:10	80.0	97.4	100.0	93.6	87.9	94.7	76.3	90.5	88.6	79.3	83.7	80%	63.4
80:15	77.3	95.1	97.8	95.6	94.1	95.7	66.7	75.6	86.1	75.0	75.9	77.6[b]	56.2
70:15	75.3	95.5	100.0	97.8	96.2	97.4	78.5	92.2	88.9	88.2	87.0	70%	63.8
80:20	69.2	94.9	97.8	98.2	93.8	96.2	78.4	80.0	89.1	86.7	83.6	84.1[a]	55.7
70:20	75.0	95.2	100.0	94.2	98.2	96.9	77.5	82.6	79.6	81.5	80.3		58.4
80:25	78.0	97.4	97.8	96.0	92.7	96.0	70.3	79.6	77.1	68.4	73.9		55.3
70:25	74.6	97.7	100.0	98.0	93.5	97.3	81.0	95.5	83.3	81.4	85.3		59.5

Means bearing atleast one same superscript do not differ significantly

* Number of chicks hatched per 100 eggs produced during the collection period only

of settable eggs than other groups. Analysis of variance on per cent fertility and hatchability data (Table 19) showed no significant differences between treatments, however feeding at 80 per cent level resulted in low hatchability than at 100 or 70 per cent levels of feeding. The data on per cent hatchability of the total eggs produced i.e., the number of chicks hatched per 100 eggs produced (during the collection period only) revealed that it did not followed any definite trend, depending upon the dietary treatments. Moreover, there was no interrelationship between these three traits and each trait responded independently. These results indicate that the variations in settability, fertility and hatchability may probably be incidental and not associated with restricted feeding.

Total Serum Cholesterol:

Total serum cholesterol levels (Table 18) were significantly affected both by restricted feeding programme and also by the age of the birds. Lower cholesterol levels were observed in the control and the shortest restricted groups and increased gradually with the intensity of restriction. Elevated cholesterol levels were observed both due to lower levels of feeding as well as due to longer durations of restriction. Negative correlation was observed between levels of feeding and levels of cholesterol but durations

Table 18. - Mean levels(mg%) of "total serum cholesterol" during and post-feed restriction periods

Treatment code	Age in weeks							Mean for treatments	Mean for levels	Mean for durations
	10	15	20	25	30	40	56			
100%	247	253	241	231	199	172	151	213.4^{d}	100%	5-10 wks
80:10	252	258	228	221	194	174	144	210.1^{d}	213.4^{c}	212.9^{b}
70:10	270	260	236	228	196	177	139	215.1^{cd}	80%	5-15 wks
80:15	255	269	248	235	216	173	146	220.3^{bc}	218.8^{b}	218.7^{ab}
70:15	262	274	241	233	214	179	154	222.4^{ab}	70%	5-20 wks
80:20	258	262	253	245	221	177	136	221.6^{ab}	222.8^{a}	220.5^{a}
70:20	266	273	257	247	219	178	146	226.6^{a}		5-25 wks
80:25	257	264	248	247	221	183	143	223.3^{ab}		221.2^{a}
70:25	267	273	255	250	219	185	141	227.1^{a}		
Mean for periods (3x4 treatments)	256.3^{b}	262.1^{a}	244.2^{c}	235.8^{d}	208.0^{e}	176.2^{f}	146.0^{g}	218.4		

Means bearing atleast one same superscript do not differ significantly ($P \angle 0.01$)

Table 19. - Analysis of variance for P.E.I., fertility, hatchability and serum cholesterol

Sl. No.	Factor	Source of variation	D.F.	M.S.	F
1.	Performance efficiency index (1-8 periods)	Due to levels	2	39.87	1.25
		Due to durations	3	3.45	0.11
		Levels X Durations	6	16.89	0.53
		Error	84	31.94	
		Total	95		
2.	Performance efficiency index (2-8 periods)	Due to levels	2	100.97	12.93**
		Due to durations	3	27.88	3.57*
		Levels X Durations	6	21.38	2.74*
		Error	72	7.81	
		Total	83		
3.	Fertility among settable eggs	Due to levels	2	77.23	2.45
		Due to durations	3	13.19	0.42
		Levels X Durations	6	40.19	1.28
		Error	36	31.52	
		Total	47		
4.	Hatchability of fertile eggs set	Due to levels	2	139.62	3.42*
		Due to durations	3	2.14	0.05
		Levels X Durations	6	28.06	0.69
		Error	36	40.80	
		Total	47		
5.	Total serum Cholesterol	Due to levels	2	1244.25	30.91**
		Due to durations	3	603.80	15.00**
		Levels X Durations	6	157.30	3.91**
		Due to periods	6	12435.72	308.89**
		Error	150	40.26	
		Total	167		

* Significant (P ∠ 0.05)

** Significant (P ∠ 0.01)

of restriction and levels of cholesterol was positively correlated. Significant differences were also observed between cholesterol levels at various ages. The highest cholesterol level was observed at 15 weeks of age and thereafter it progressively declined. Similar observations were made by Nichols and Balloun (1963), who reported that by restricting the feed intake to 70 per cent of ad libitum, the serum cholesterol concentrations tended to be higher at 16 weeks of age. Reddy (1971) also noticed elevated serum cholesterol levels in restricted groups, which followed a linear pattern depending upon the severity of restriction and decreased with the advancement in age of the birds.

When full-feeding was restored to among the restricted groups, the elevated serum cholesterol levels became reduced and matched those of the control group. Hence, the differences in serum cholesterol levels between the hens of different groups were quite negligible. Similarly, Reddy (1972) reported that the blood serum cholesterol, which was high among the restricted groups during the growing period, was reduced to a level comparable to the ad libitum group, during the laying period.

The lowered cholesterol levels in all the groups during laying period may be attributed, atleast in part, due to inclusion of choline choloride in the breeder mash from 29 weeks of age, in order to prevent F.L.H.S. This is in accordance with the observations made by Treat et al. (1960), who reported that the dietary choline decreased the serum cholesterol levels.

Mortality:

The data on per cent mortality and the reasons thereof based on autopsical findings are reported in Tables 20 and 21 respectively. There was no mortality at all in the control group during the entire experimental period, whereas mortality was observed to some extent among all the restricted groups and was the highest in the 70:10 group and lowest in 70:15 and 80:20 groups. These results indicate, that the mortality rate did not followed any definite trend in relation to the dietary treatments.

During the restriction period no mortality was recorded in any of the groups, except in the two longest restricted groups. Nevertheless, the deaths in these groups were not associated with restricted feeding programme, with the exception of one case as reported in Table 21. This revealed that the various feed restriction programmes during the rearing period had little effect on the rearing mortality. Similarly, Schneider et al. (1966) and Luckham et al. (1963) noticed, no significant differences in growing mortality due

Table 20. - Per cent mortality at various ages among the experimental birds

Treatment code	0-4[1] weeks	5-25[2] weeks	26-55[3] weeks	0-55 weeks	Number survived/number started
100%	-	-	-	-	28/28
80:10	-	17.86	4.35	21.43	22/28
70:10	3.57	18.52	9.09	28.57	20/28
80:15	3.57	3.70	7.69	14.29	24/28
70:15	-	-	3.57	3.57	27/28
80:20	-	-	3.57	3.57	27/28
70:20	3.57	-	7.41	10.71	25/28
80:25	3.57	18.52	-	21.43	22/28
70:25	3.57	3.70	11.54	17.86	23/28
Mean for periods	1.98	6.83	5.22	13.49*	218/252

1. Per cent mortality during pre-restriction period

2. Per cent mortality during rearing period

3. Per cent mortality during laying period

* Per cent mortality for the whole flock during the entire experimental period

Table 21. - Causes of mortality of the experimental birds during the experimental period (0-55 weeks)

Treatment code	Number dead due to						Total dead under each treatment
	Intestinal coccidiosis[1]	A.L.C.[2]	Egg peritonitis and egg bound	Haemorrhagic syndrome	Emaciation and weakness[3]	Non-specific causes	
100%	-	-	-	-	-	-	-
80:10	5	-	1	-	-	-	6
70:10	4	-	1	1	-	2	8
80:15	1	-	-	-	-	3	4
70:15	-	-	-	-	-	1	1
80:20	-	-	1	-	-	-	1
70:20	-	1	1	-	-	1	3
80:25	5	-	-	-	-	1	6
70:25	-	-	1	1	1	2	5
Total for causes of mortality	15	1	5	2	1	10	34

1. Caused by *Eimeria tenella*
2. Avian Leucosis Complex : Visceral lymphomatosis form
3. Probably due to feed restriction

to restricted feeding; whereas Fuller <u>et al.</u> (1959), Gowe <u>et al.</u> (1960 b) and Strain et al. (1965) observed increased rearing mortality under restricted feeding regimens.

It may be noticed from Table 21, that about 50 per cent of the mortality was due to Intestinal Coccidiosis, which occured around 21 weeks of age. The occurance of Coccidiosis among various experimental groups was quite erratic and no conclusion could be drawn for any association between dietary treatments and occurance of Coccidiosis. Except for this out break, mortality was generally low for the whole flock.

During laying period the mortality in all groups was low, except in 70:10 and 70:25 groups in which it was slightly high. But in all these cases, the mortality was not associated with restricted feeding programme. Deaton and Quisenberry (1963) and Lillie and Denton (1966) similarly observed that the rearing period feed restriction was not associated with adult mortality. On the other hand, Fuller and Dunahoo (1962) and Jones (1968) reported lowered adult mortality in restricted groups.

In general, the data on rate of mortality revealed that there was no association between rate of mortality and levels or durations of feed restriction. The occurance of mortality appeared to be purely incidental and hence no conclusions could be drawn between the rate or causes of death and feed restriction.

Net Feed Efficiency(NFE):

The data on NFE as shown in Table 22 and Figure 5 revealed that the best NFE was achieved by 80:25 group, closely followed by 70:20 and other restricted groups. The better NFE values with the restricted groups, indicate that these groups had either developed an apparent adaptive process for low maintenance requirement of the feed as believed by Sanslone and Squibb (1963) or digested the feed better than the full-fed control group as reported by Mahapatro et al.(1968).

In general, the restricted groups showed better NFE values than the control group; eventhough all the restricted groups recorded some sort of mortality. If NFE were to be calculated per survival pullet, it would have resulted in still better NFE values, in favour of restricted groups.

NFE values closely followed the trend of feed efficiency values, as calculated by kilograms of feed consumed (0-55 wks) per kilogram or one dozen eggs; except for some minor variations, due to differences in final body weights. This indicates that the NFE is also an effective method of measuring the real feed utilization.

Table 22. - Net feed efficiency for each treatment as a whole under different levels and durations of feed restriction during rearing period

Treatment code	Total mass of the eggs produced (gm.)	Total weight gain (0-55 wks) (gm.)	Net production (columns 2+3) (gm.)	Total feed intake (0-55 wks) (gm.)	N.F.E Column 5 / Column 4	Deviation of N.F.E. over control group	Per cent deviation over control group
1	2	3	4	5	6	7	8
100%	186475	42868	229343	850530	3.71	-	-
80:10	154097	33990	188087	711180	3.78	−0.07	−1.89
70:10	152506	30700	183206	678500	3.70	0.01	0.27
80:15	172620	38208	210828	740760	3.51	0.20	5.39
70:15	200207	43065	243272	830750	3.41	0.30	8.09
80:20	200430	41283	241713	854990	3.54	0.17	4.58
70:20	184325	37750	222075	749010	3.37	0.34	9.16
80:25	163686	33836	197522	653670	3.31	0.40	10.78
70:25	162396	33833	196229	708850	3.61	0.10	2.70

Economic Significance:

Relative economy in feed utilization and relative feed intake per unit production (Table 23 and Figure 5) revealed that in general, restricted groups utilized the feed more economically than the full-fed group, by way of consuming less feed per unit production. The best feed economy was achieved with the 80:25 group, followed by 70:20 and other restricted groups. The comparatively poor feed economy in 80:10 group was partly due to higher mortality of ready-to-lay pullets and comparatively low egg production in this particular group.

It may be seen from Table 24 that the income per pullet started or per pullet at the commencement of feed restriction is generally in favour of the restricted groups, especially those which were restricted for longer periods (except 70:25 group). Income per pullet housed or per survival pullet manifested a much more favourable trend for longer restricted groups. The 80:25 group resulted in the highest monetary returns, when income was calculated either per pullet housed or per survival pullet. If income was reported per pullet started or per pullet at the commencement of feed restriction the income in this group (80:25) was less, because of death of pullets prior to housing time, due to Coccidiosis. Income per pullet started or per pullet at the start of feed restriction was high in 70:15, 70:20 and 80:20 groups.

Table 23. - Relative feed intake/unit production and economy in feed utilization under different dietary regimens

Treatment code	Feed saved or lost/unit of production in comparison to control as measured by					Relative economy in feed utilization (mean of columns 2 to 6)	Relative feed intake per unit production
	N.F.E.	Feed intake (0-55 wks) / egg mass	Feed intake (1st egg to 55 wks) / egg mass	Kgs. of feed consumed (0-55 wks) / dozens of eggs produced	Kgs. of feed consumed (1st egg to 55 wks) / dozens of eggs produced		
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	2	3	4	5	6	7	8
100%	0.00	0.00	0.00	0.00	0.00	0.00	100.00
80:10	-1.89	-1.32	3.01	-2.52	1.35	-0.27	100.27
70:10	0.27	2.41	6.30	2.52	6.31	3.56	96.44
80:15	5.39	5.92	6.03	6.47	6.76	6.11	93.89
70:15	8.09	8.99	7.67	7.19	5.41	7.47	92.53
80:20	4.58	6.36	5.48	6.12	4.95	5.50	94.50
70:20	9.16	10.96	12.05	7.55	8.11	9.57	90.43
80:25	10.78	12.50	15.62	8.99	12.16	12.01	87.99
70:25	2.70	4.30	9.86	1.80	7.21	5.19	94.81

Table 24. - Influence of feed restriction in growing pullets on the income over feed cost

Treatment code	Income from eggs/group*	Income from spent-hens/group**	Gross income/group (columns 2+3)	Cost of feed (0-56 wks)/group@	Income over feed cost: Per group (column 4 - 5)	Per chick started	Per chick at the start of feed restriction	Per pullet housed	Income Per surviving pullet
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)
1	2	3	4	5	6	7	8	9	10
100%	999.00	218.82	1217.82	850.53	367.29	13.12	13.12	13.12	13.12
80:10	825.48	173.58	999.06	711.18	287.88	10.28	10.28	12.52	14.31
70:10	816.84	156.80	973.64	678.50	295.14	10.54	10.93	13.42	16.13
80:15	924.84	195.36	1120.20	740.76	379.44	13.55	14.05	14.59	16.50
70:15	1072.44	219.92	1292.36	830.75	461.61	16.49	16.49	16.49	16.88
80:20	1073.88	210.87	1284.75	854.99	429.76	15.35	15.35	15.35	15.67
70:20	987.48	192.88	1180.36	749.01	431.35	15.41	15.98	15.98	16.83
80:25	876.96	173.03	1049.99	653.67	396.32	14.15	14.68	18.01	19.48
70:25	870.12	172.85	1042.97	708.85	334.12	11.93	12.37	12.85	14.45

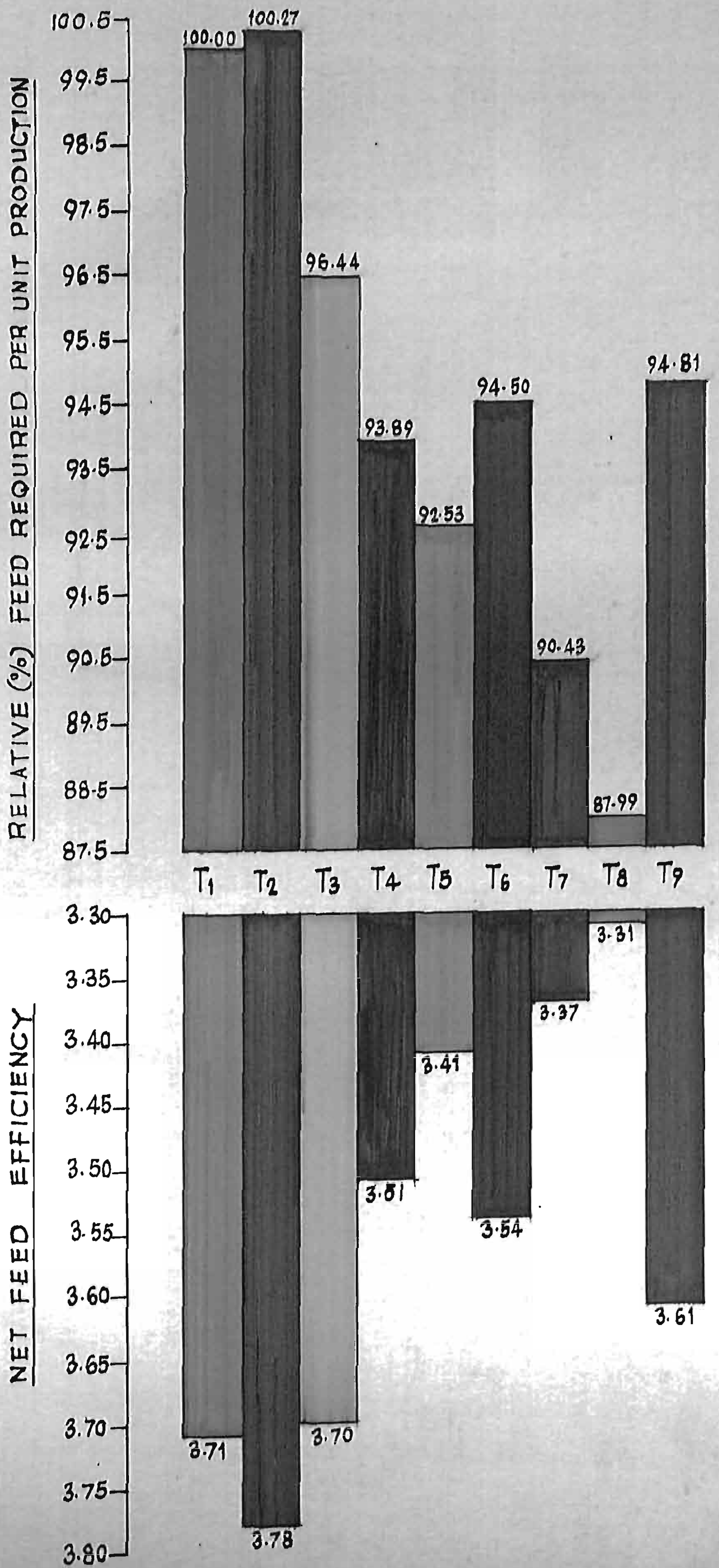
* Assuming the cost of eggs at Rs.3.60/doz.(24 ozs.)

** Assuming the cost of spent-hens at Rs.5/kg. of live weight

@ Assuming the cost of feed at Rs.1000/tonne

FIGURE: 5

INFLUENCE OF RESTRICTED FEEDING OF GROWING PULLETS UPON RELATIVE(%) FEED REQUIRED PER UNIT PRODUCTION & NET FEED EFFICIENCY.



In general, the longer restricted groups had shown better feed economy and higher monetary returns than the control or shorter restricted groups. Similarly, Gowe *et al.* (1960 a and 1965), Isaacks *et al.* (1960), Hollands and Gowe (1965) and Vaidya (1971) reported higher monetary returns from restricted groups. However, Proudfoot and Gowe (1967) noticed that the feed restriction during rearing period failed to improve the economic traits. If the performance was studied for one full laying-year, the restricted groups probably would have exhibited still greater economy because these groups which showed better egg production till the end of the study (55 wks), could also be expected to continue laying at a higher rate towards the end of their laying year.

Restricted feeding programme involves slightly higher labour cost than *ad libitum* feeding system, since frequent feeding and weighing of feed is necessary. Similarly Novikoff and Biely (1945) reported that the restricted feeding system involved greater amount of labour.

EXPERIMENT II

Weight Gains And Feed Efficiency:

Weight gains from 29 to 53 days of age, that is during the period of feed restriction were significantly lower($P < 0.01$) at both levels of feed restriction (80 or 70% of *ad libitum*) when compared with the full-fed controls. However, the restricted groups exhibited better feed efficiency than the controls during the same period. For the earlier period (2-4 wks) better feed efficiency was recorded than during the later periods (4-7½ wks) irrespective of the nature of dietary treatment. These results indicate better feed utilization at younger age than subsequently.

Nutrient Utilization:

The data on nutrient utilization are shown in Table 26. While the nitrogen retention was improved by feed intake at 70 per cent of ad libitum, no differences were observed between 80 and 100 per cent levels of feeding. This finding suggests that there is probably a better utilization of protein at 70 per cent level of feed intake. Contrary to this results Vaidya (1971) observed no differences in the utilization of nitrogen between full-fed and restricted groups.

Metabolizable dry matter (MDM) and metabolizable energy (Table 27) of the feed were not affected by the restricted feeding programme supporting the observations of Hill and Anderson (1955), who observed that the metabolizable energy was unaffected by level of feed intake from 30 to 100 per cent.

Nitrogen retention, MDM and metabolizable energy values of the diet were fairly influenced by the age of the birds.

Table 26. - Effect of restricted feeding upon the performance of the chicks and nutrient utilization (Experiment-II)

Treatment code	Replication number	Mean weight gain (gm.) during		Feed/gain during		Nitrogen@ retention (mg./gm.) during		Metabolizability@ (%) during		Metabolizable@ energy (K.Cal/kg.)		Actual levels of feeding achieved (%)
		2-4 wks	4-7½ wks**	2-4 wks	4-7½ wks**	4th wk.*	8th wk.**	4th wk.*	8th wk.**	4th wk.*	8th wk**	
	1	113	187	2.61	4.43	9.98	7.37	56.07	54.09	2629	2547	
100%	2	110	195	2.65	4.44	10.06	7.53	56.41	54.73	2638	2570	
	Mean	111.5	191.0[a]	2.63	4.44	10.02	7.45	56.24	54.41	2634	2559	100
	1	115	143	2.55	4.12	9.18	7.57	56.61	53.72	2654	2527	
80%	2	113	149	2.61	4.04	9.12	7.22	56.39	54.78	2631	2557	
	Mean	114	146[b]	2.58	4.08	9.15	7.40	56.50	54.25	2643	2542	76
	1	110	129	2.66	4.18	9.38	9.38	56.89	54.24	2635	2553	
70%	2	109	126	2.67	4.06	10.08	8.96	56.17	54.90	2621	2581	
	Mean	109.5	127.5[b]	2.67	4.12	9.73	9.17	56.53	54.57	2628	2567	67

* Before feed restriction

** During feed restriction

@ All values expressed on dry matter basis

Mean body weight gains bearing atleast one same superscript do not differ significantly ($P \angle 0.01$)

All these values were higher during the 4th week rather than during the 8th week of age. This is suggestive of better nutrient utilisation at lesser age. Similarly, Sibbald et al. (1959) and Zelenka (1968) reported that the metabolizable energy content of feed ingredients differed significantly when fed to chicks of different ages.

Table 27.-Analysis of variance for weight gains during restriction period(Experiment II)

Source of variation	D.F.	M.S.	F
Due to treatments	2	46599.65	22.19**
Error	87	2099.67	
Total	89		

** Significant(P/_ 0.01)

SUMMARY AND CONCLUSIONS

An experiment was conducted over a 55 week duration with egg-type pullet chicks which were reared on litter floor pens. They were fed to appetite and at 80 or 70 per cent levels for varying durations ranging from 5 to 10, 15, 20 or 25 weeks of age. For each treatment cumulative feed intake, individual body weights at various ages, feed efficiency, age at sexual maturity, total serum cholesterol levels and mortality were recorded. Laying house performance was studied for 8 X 28-day periods, starting from the beginning of 24th week. Based on the data collected relative economy in feed utilization and income over feed cost were calculated. The following conclusions were drawn from this study.

1. Feed efficiency was slightly better in restricted groups both during growing and laying periods.

2. Feed consumption among the restricted groups during the growing period (0-25 wks) was less than the control group but the feed intake during laying period (26-55 wks) or the overall feed consumption (0-55 wks) was variable and followed no particular trend.

3. The body weights of the birds fed at 70 per cent of *ad libitum* were significantly lighter than the control during their respective duration of feed restriction. Those birds which were fed at 80 per cent of *ad libitum* were significantly lighter than the control birds only

in the case of the group restricted from 5-25 weeks of age at 23 and 25 weeks of age. By 31st week of age all groups attained more or less uniform body weights and maintained the same till the end of the experiment.

4. Restriction for shorter durations such as 5-15 weeks of age or less did not result in any appreciable delay in sexual maturity. Whereas in those groups where the restriction was prolonged upto 20 weeks or longer, the age to reach the point of lay was delayed to a considerable extent, irrespective of the level of restriction. However, those groups which laid their first egg earlier needed relatively longer time to reach the peak production from the day of their first egg.

5. No significant difference in egg production during 24-55 weeks of age (1-8 periods) was observed between various regimens of feed restriction. But the egg production from 28-55 weeks of age (2-8 periods) was significantly better at 80 and 70 per cent levels of feeding than the full-fed control. A notable difference in favour of restricted groups was also observed, when egg production in each treatment was adjusted according to the different maturity dates of the respective groups.

6. Feed restriction for longer durations i.e., 5-20 or 5-25 weeks of age, considerably reduced the number of

small eggs laid during the early part of the laying period.

7. Better performance efficiency index was recorded for the restricted groups than the control group.

8. No mortality was noticed in the control group throughout the experimental period. Although some mortality was observed among all the restricted groups, it appeared to be unassociated to the feed restriction programmes used.

9. Eventhough some differences were observed in the settability, fertility and hatchability, it could not be incriminated to the dietary treatments.

10. Total serum cholesterol levels were elevated by feed restriction but resumed normal levels after the restriction was removed. Levels of feeding and levels of cholesterol were negatively correlated but the durations of restriction and levels of cholesterol were positively correlated.

11. Net feed efficiency was better among the restricted groups in comparison to the control group.

12. All feed restriction programmes resulted in better feed utilization and relatively greater feed economy and higher

Table 25. - Effect of different levels and durations of feed restriction during rearing period upon the overall performance of pullets (Summary)

Sl. No.	Factor	100% (control)	80:10	70:10	80:15	70:15	80:20	70:20	80:25	70:25
1.	Actual levels of feeding achieved, during the restriction period (%)	100.0	84.2	73.8	83.5	73.1	83.6	73.1	80.2	70.6
2.	Mean feed consumption upto first egg (gm.)	6045	5914	5804	5526	5565	5875	5808	5653	6482
3.	Mean feed consumption upto 10% production (gm.)	6679	6414	6401	5634	5855	5945	6058	6223	6932
4.	Mean feed consumption upto 50% production (gm.)	7728	7626	7259	7471	6900	7106	7126	7850	7190
5.	Mean feed consumption from 0-25 wks of age(gm.)	8297	7986	7959	7657	7699	7541	6956	6914	6082
6.	Mean feed consumption from 26-55 wks of age(gm.)	22079	21685	22700	20587	22258	23272	22470	21295	22117
7.	Mean feed consumption from 0-55 wks of age (gm.)	30376	29671	30659	28244	29957	30813	29426	28209	28199
8.	Mean housing body weight (gm.)	1182	1145	1147	1135	1166	1167	1132	1084	1011
9.	Mean final body weight (gm.)	1563	1578	1568	1628	1629	1562	1543	1573	1503
10.	Per cent hen-day egg production (1st egg to 55 wks)	55.2	56.4	60.9	56.8	59.7	62.2	61.5	62.5	61.2
11.	Per cent hen-housed egg production (1st egg to 55 wks)	55.2	55.0	57.9	55.1	59.0	61.6	58.2	62.5	58.1
12.	Population mean egg mass (gm.)	50.7	51.4	50.7	50.4	51.8	51.0	52.8	52.7	52.1
13.	Mean mass of the eggs produced on the 10th day after first egg (gm.)	38.4	42.0	38.3	37.9	38.8	41.5	42.4	38.8	47.1
14.	Overall feed efficiency (feed/gain) from 5-25 wks	6.90	6.84	6.88	6.69	6.56	6.32	6.02	6.30	5.96
15.	Overall feed efficiency (kgs. of feed consumed from 1st egg to 55 wks/dozens of eggs produced)	2.22	2.19	2.08	2.07	2.10	2.11	2.04	1.95	2.06
16.	Overall feed efficiency (kgs. of feed consumed from 1st egg to 55 wks/kgs.of eggs produced)	3.65	3.54	3.42	3.43	3.37	3.45	3.21	3.08	3.29

Table 25. - continued from previous page

17. Overall feed efficiency (kgs.of feed consumed from 0-55 wks/dozens of eggs produced)	2.78	2.85	2.71	2.60	2.58	2.61	2.57	2.53	2.73
18. Overall feed efficiency (kgs.of feed consumed from 0-55 wks/kgs. of eggs produced)	4.56	4.62	4.45	4.29	4.15	4.27	4.06	3.99	4.36
19. Net feed efficiency (N.F.E.)	3.71	3.78	3.70	3.51	3.41	3.54	3.37	3.31	3.61
20. Performance efficiency index (mean for 1-8 pds.)	30.6	31.1	32.2	32.6	32.5	31.3	33.6	35.1	30.9
21. Age at first egg (days)	147	148	149	146	151	157	163	159	179
22. Age to attain 10% production (days)	157	156	158	149	155	158	166	169	184
23. Age to attain 50% production (days)	170	172	169	173	169	171	178	186	189
24. Age to attain peak production (days)	179	178	177	182	177	178	185	191	195
25. Per cent settable eggs	72.8	79.0	80.0	76.9	75.3	69.2	75.0	78.0	74.6
26. Per cent fertility among the eggs set	98.4	99.4	94.7	95.7	97.4	96.2	96.9	96.0	97.3
27. Per cent hatchability over fertile eggs set	84.2	76.9	83.7	75.9	87.0	83.6	80.3	73.9	85.3
28. Hatchability over total eggs produced during the collection period (%)	69.3	60.4	63.4	56.2	63.8	55.7	58.4	55.3	59.5
29. Per cent mortality	0.0	21.4	28.6	14.3	3.6	3.6	10.7	21.4	17.9
30. Mean levels of "Total serum cholesterol"(mg.%)	213	210	215	220	222	222	227	223	227
31. Relative feed intake/unit production (%)	100.00	100.27	96.44	93.89	92.53	94.50	90.43	87.99	94.81
32. Relative economy in feed utilization (%)	0.00	— 0.27	3.56	6.11	7.47	5.50	9.57	12.01	5.19
33. Income over feed (0-55 wks)/each treatment as a whole (Rs.)	367.29	227.88	236.14	379.44	461.61	429.76	431.35	396.32	334.12
34. Income over feed cost (0-55 wks)/surviving pullet	13.12	14.31	16.13	16.50	16.88	15.67	16.83	19.48	14.45

monetary returns except the group restricted for the shortest period (5-10 wks). Feeding at 70 or 80 per cent of *ad libitum* from 5 to 20 or 25 weeks of age respectively seems to be an ideal rearing methods, compared to other regimens of restriction.

A second experiment was conducted over a 53 days period with White Leghorn pullet chicks reared on wire floor, to estimate whether the restricted feeding programme (80 and 70% of *ad libitum* from 26-53 days of age) had any effect on nitrogen retention, metabolizable dry matter and metabolizable energy content of the diet and the following conclusions were drawn.

1. Nitrogen retention was better with the group restricted to 70 per cent of *ad libitum* feeding but no differences were observed between the full-fed and the 80 per cent fed groups.
2. Metabolizable dry matter and metabolizable energy values were not affected by the regimens of feed restriction.
3. Nitrogen retention, metabolizability and metabolizable energy values of the same diet were higher during the 4th week, rather than during the 8th week of age, suggesting better utilization of nutrients at younger age than later.

LITERATURE CITED

Abbott, W.W., and J.R. Couch, 1971. An evaluation of the various methods of delaying sexual maturity and their effects upon subsequent reproductive performance of broiler breeder replacement pullets. Poultry Sci.50:1542.

Adams, R.L., B.B. Bohren and J.P. Carson, 1967. Delaying sexual maturity by restricting feed or by feeding 6-chloro-delta 6-17 acetoxy progresterone (CAP). Experiment 2. Poultry Sci. 46:1226-1227.

Arbor Acres Review, 1965. Skip-a-day pullet feeding, Poultty Dig. 24:325-327.

Association of Official Analytical Chemists, 1970. Official Methods of Analysis. 11th ed., Washington, D.C. 20044.

Berg, L.R., and G.E. Bearse, 1961. Restricted feeding with restricted light for developing pullets. Poultry Sci.40: 180-185.

Biely, J., and B.E. March, 1959. Genetic and nutritional effects on the incidence of Avian Leucosis Complex. Poultry Sci. 38:1102.

Britzman, D.G., R.E. Gray and E.J. Strandine, 1965. The effect of various dietary growing regimes upon the performance of broiler breeders. Poultry Sci. 44:1355.

Bullock, D.W., T.R. Morris and S.Fox, 1963. Protein and energy restriction of replacement pullets. Brit. Poultry Sci. 4: 227-237.

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

Cooper, J.B., and B.D. Barnett, 1960. Restriction of feed by controlling calorie intake per volume of feed. Poultry Sci.39:1240.

Couch, J.R., J.H. Trammell and A. Tolan, 1970. Effect of low lysine diets on growth and subsequent reproductive performance of broiler breeder pullets. Nutrition Abst. and Rev., (Abst. 8644) 40:1309.

Dansky, L.M., and F.W. Hill, 1952. Application of the chromic oxide indicator method to balance studies with growing chickens. J. Nutrition 47:449-459.

Davis, W.M., and A.B. Watts, 1955. The effect of ration treatment during the various stages of the chicken's life upon the subsequent performance of laying hens. Poultry Sci. 34:1231-1232.

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

Denton, C.A., and R.J. Lillie, 1959. Effect of protein restriction in growing and laying diets on the performance of White Leghorn pullets. Poultry Sci.38:1198.

Donaldson, W.E., and R.I. Millar, 1961. Effects of energy restriction on meat-type laying hens. Poultry Sci. 40:1395.

Donaldson, W.E., and R.I. Millar, 1962. Effects of energy restriction on laying hens. Poultry Sci.41:353-369.

Dronawat, N.S., and J. McGinnis, 1966. Effect of feed restriction and of limiting feeding time for laying hens on egg production, egg size and feed consumption. Poultry Sci. 45:1081.

Ewing, W.R., 1963. Poultry nutrition. 5th ed., the Ray Ewing Company, Pasadena, California.

Frank, F.R., and P.E. Waibel, 1960. Effect of dietary energy and protein levels and energy source on White Leghorn hens in cages. Poultry Sci. 39:1049-1056.

Fuller, H.L., 1959. Restricted feeding of pullets. 1.Effect of restricting starting Vs. growing ration. Poultry Sci. 38:1206.

Fuller, H.L., W.S. Dunahoo and H.M. Edwards Jr., 1959. Restricted feeding of pullets. 2. Effect of age of pullets and duration of restriction. Poultry Sci. 38:1206-1207.

Fuller, H.L., 1962. Restricted feeding of pullets. 1. The value of pasture and self selection of dietary components. Poultry Sci. 41:1729-1736.

Fuller, H.L., and W.S. Dunahoo, 1962. Restricted feeding of pullets. 2. Effect of duration and time of restriction on three-year laying house performance. Poultry Sci.41:1306-1314.

Fuller, H.L., D.K. Potter and W. Kirkland, 1969. Effect of delayed maturity and carcass fat on reproductive performance of broiler breeder pullets. Poultry Sci.48:801-809.

Fuller, H.L., W.M. Kirkland and L.W. Chaney, 1973. Methods of delaying sexual maturity of pullets. 2. Restricting energy consumption. Poultry Sci.52:228-237.

Gerry, R.W., and F.V. Muir, 1972. The effect of feed restriction of brown egg-laying hens. Poultry Sci.51:1811.

Gowe, R.S., K.G. Hollands, and P. Hull, 1960a. Economic and genetic implications of restricted feeding during the the rearing period for egg production stock. Poultry Sci. 39:1254.

Gowe, R.S., A.S. Johnson, R.D. Crawford, H.J. Downs, A.T. Hill, W.F. Mountain, J.R. Pelletier and J.H. Strain, 1960b. Restricted versus full-feeding during the growing period for egg production stock. Brit. Poultry Sci.1:37-56.

Gowe, R.S., and J.A. Lemay, 1961. The importance of the interaction of commercial strains of egg production chickens with two-rearing programmes - Restricted feeding and full feeding. Poultry Sci. 40:1410.

Gowe, R.S., J.H. Strain, R.D. Crawford, A.T. Hill, S.B. Slen and W.F. Mountain, 1965. Restricted feeding of growing pullets. 2. The effect on costs, returns and profits. Poultry Sci. 44:717-726.

Han, P.F.S., and J.R. Smyth, Jr., 1972. The influence of restricted feed intake on the response of chickens to Marek's disease. Poultry Sci. 51:986-990.

Hewitt, D., and D. Lewis, 1972. The effect of dietary lysine level, restriction of food intake and sampling time on the levels of amino acids in the blood plasma of chicks. Brit. poultry Sci. 13:387-398.

Heywang, B.W., 1940. The effect of restricted feed intake on egg weight, egg production and body weight. Poultry Sci. 19:29-34.

Hill, F.W., and D.L. Anderson, 1955. Comparison of productive energy and metabolizable energy determinations with chicks. Poultry Sci. 34:1201.

Hill, F.W., and D.L. Anderson, 1958. Comparison of metabolizable energy and productive energy determination with growing chicks. J. Nutrition 64:587-603.

Hollands, K.G., and R.S. Gowe, 1961. The effect of restricted and full-feeding during confinement rearing on first and second year laying house performance. Poultry Sci. 40:574-5

Hollands, K.G., and R.S. Gowe, 1965. The economic value of restricted and full-feeding during confinement rearing on two-year egg-production. Brit. Poultry Sci.6:227-235.

Howes, J.R., and G.J. Cottier, 1965. The delay in maturity of heavy breeders as affected by diet. Poultry Sci.44: 1382-1383.

Iino, M., K. Ogata, M. Fujihara and M. Yoshida, 1969. Studies on the grower diet for meat-type pullet. 1. Effects of high fibre diet feeding and skip-a-day in a week. Nutrition Abst. and Rev., (Abst. 1811) 39:292.

Iino, M., K. Mizutani, H. Mekada, M. Iwao, K. Ogata and M. Yoshida, 1970. Studies on the grower diet for meat-type pullet. 4. Effect of feeding programmes of skip-a-day in two or three days. Nutrition Abst. and Rev., (Abst. 6545) 40:1122.

Indian Standards Institution, 1968. Indian Standard specification for poultry feeds, IS: 1374, Manak Bhavan, 9 Bhadurshah Zafar Marg, New Delhi-1.

Isaacks, R.E., J.H. Quisenberry, B.L. Reid and J.R. Couch, 1958. Restricted feeding of broiler type replacement pullets. Poultry Sci. 37:1215.

Isaacks, R.E., B.L. Reid, R.E. Davies, J.H. Quisenberry and J.R. Couch, 1960. Restricted feeding of Broiler type replacement stock. Poultry Sci. 39:339-346.

Jackson, N., and W.O. Brown, 1969. The effect of restriction of daily energy intake on the efficiency of egg production in the hen. Nutrition Abst. and Rev., (Abst.4086) 39:684-68

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

Jones, M.L., 1968. Feed restriction of 6-week old broiler breeder chickens. Poultry Sci. 47:1685-1686.

Kirkland, W.M., and H.L. Fuller, 1971. Methods of delaying sexual maturity of pullets. 1. water restriction. Poultry Sci. 50:1761-1767.

Leveille, G.A., 1969. In vivo fatty acid and cholesterol synthesis in fasted and fasted-re-fed chicks. J. Nutrition. 98:367-372.

Lillie, R.J., and C.A. Denton, 1966. Effect of nutrient restriction on White Leghorns in the grower and subsequent layer periods. Poultry Sci. 45:810-818.

Luckham, D.G., S.J. Slinger, I.R. Sibbald and G.C. Ashton, 1963. Methods of restricting feed or energy intake of growing Leghorn pullets and their effect on subsequent reproductive performance. Poultry Sci. 42:1285.

MacIntyre, T.M. and E.E. Gardiner, 1961. The effect of restricting the feed intake of confinement reared pullets on future performance. Poultry Sci. 40:1425.

MacIntyre, T.M., and E.E. Gardiner, 1964. Effect of duration of feed restriction on the laying house performance of confinement reared pullets. Poultry Sci. 43:467-473.

Mahapatro, B.B., N. Patnaik and H.P. Misra, 1968. Efficiency of weight gain and rate of passage of feed through the digestive tract of chicks at different levels of feeding. Indian Vet. J. 45:145-150.

Manoukas, A.G., N.F. Colovos and H.A. Davis, 1964. Losses of energy and nitrogen in drying excreta of hens. Poultry Sci. 43:547-549.

Milby, T.T., and D.H. Sherwood, 1953. The effect of restricted feeding on growth and subsequent production of pullets. Poultry Sci. 32:916.

Milby, T.T., and D.H. Sherwood, 1956. The influence of feed intake during the growing period on the subsequent performance of laying hens. Poultry Sci. 35:863-869.

Morgan, W., and C.W. Carlson, 1968. Proposed measure of performance efficiency in laying hens. Poultry Sci. 47:22-26.

Nichols, E.L., and S.L. Balloun, 1963. Dietary effects on blood pressure. 2. Effects of dietary restriction. Poultry Sci. 42:1295.

Novikoff, M., and J. Biely, 1945. Observations on two methods of feeding chickens from one day old to twelve months of age. Poultry Sci. 24:245-251.

Patel, P.R., and J. McGinnis, 1970. Effect of restricted feeding time on feed consumption, egg production and body weight gain of Leghorn pullets. Poultry Sci.49:1425.

Patric, H., 1962. General recommendations for restricted feed management in poultry . Indian Vet. J. 39:456.

Pepper, W.F., S.J. Slinger, H.L. Orr and E.S. Snyder, 1959. Effect of high and low energy diets and range verses confinement rearing on egg production and quality of fresh and held eggs. Poultry Sci. 38:379-386.

Pepper, W.F., S.J. Slinger and G.C. Ashton, 1961. The effect of unidentified growth factor sources and restricted feeding on the performance of egg-strain chickens. Poultry Sci. 40:588-597.

Polin, D., and J.H. Wolford, 1971. Egg production by W.L. adult females restricted in feed intake by limiting their time or alloted amount to eat. Poultry Sci.50:1618.

Polin, D., and J.H. Wolford, 1972. The effect of meal-eating on egg production and body weight of White Leghorn chickens. Poultry Sci. 51:1109-1118.

Proudfoot, F.G., and R.S. Gowe, 1967. The effect of photoperiodism and rearing period feed restriction on the performance of five Leghorn strains. Poultry Sci. 46: 1056.1072.

Proudfoot, F.G., and W.F. Lamoreux, 1973. The bio-economic effect of nutrient intake restrictions during the rearing period and post "peak" egg production feed restriction on four commercial meat-type parental genotypes. Poultry Sci. 52:1269-1282.

Querner, H., and K. Becker, 1963. Effect of different methods of restricted feeding during the pullet period on the maturity and egg production. Nutrition Abst. and Rev., (Abst. 5416) 33:897.

Quisenberry, J.H., J.W., Deaton, D.C. Ferabee and J.W.Bradley, 1959. Some effects of caloric restriction during the growing period on the laying house performance of a commercial egg production stock. Poultry Sci. 38:1239.

Quisenberry, J.H., and J.W. Bradley, 1962. Effects of dietary protein and changes in energy levels on the laying house performance of egg production stocks. Poultry Sci. 41: 717-724.

Reddy, K.S., 1971. Studies on feed restriction in growing pullets. M.Sc. (Vety.) Thesis. Andhra Pradesh Agricultural University, Hyderabad.

Reddy, P.R., 1972. Effect of restricted feeding in growing pullets on their subsequent laying house performance. M.Sc. (Vety.) Thesis, Andhra Pradesh Agricultural University Hyderabad.

Reddy, C.V., K.S. Reddy, P.R. Reddy and S.M. Siddiqui, 1974. Influence of feed restriction in growing pullets on their laying house performance. Indian J. Anim. Sci. 44: In press.

Rose, R.J., and S.L. Balloun, 1966. Effects of energy or protein on cockerels. Poultry Sci. 45:1119.

Sanslone, W.R., and R.L. Squibb, 1963. Effect of calorie intake on nitrogen retention in the immature fowl. Brit. J. Nutrition 17:459-463.

Schneider, A.J., B.B. Bohren and V.L. Anderson, 1955. The effect of restricted feeding on several genetically controlled characters in the fowl. Poultry Sci. 34:691-702.

Schumaier, G., and J. McGinnis, 1969. Effects of limited time feeding system on reproductive performance of heavy breed pullets. Poultry Sci. 48:949-953.

Schurch, A.F., L.E. Lloyd and E.W. Crampton, 1950. The use of chromic oxide as an index for determining the digestibility of a diet. J. Nutrition 41:629-636.

Shannon, D.W.F., and W.O. Brown, 1969. Losses of energy and nitrogen on drying poultry excreta. Poultry Sci. 48:41-48.

Sherwood, D.H., and T.T. Milby, 1954. Restricted versus full-feeding for growing pullets. Poultry Sci.33:1080.

Sherwood, D.H., 1959. Restricting feed intake of meat-type breeder chickens. Poultry Sci. 38:1246.

Sherwood, D.H., 1960. Methods of delaying pullet maturity Poultry Sci. 39:1293-1294.

Sherwood, D.H., C.D. Caskey, B.A. Krautman, M.C. Van Wormer, S.B. Smith and R.E. Ward, 1964. Management and feeding of meat-type breeder chickens. Poultry Sci.43:1272-1273.

Sibbald , I.R., J.D. Summers and S.J. Slinger, 1959. Factors affecting the metabolizable energy content of poultry feeds. Poultry Sci. 38:1247.

Sibbald, I.R., S.J. Slinger and G.C. Ashton, 1960a. The metabolizable energy content of a chick starter diet diluted with cellulose and with kaolin. Poultry Sci. 39: 1294-1295.

Sibbald, I.R., J.D. Summers and S.J. Slinger, 1960 b. Factors affecting the metabolizable energy content of poultry feeds. Poultry Sci. 39:544-556.

Sibbald, I.R., S.J. Slinger, and G.C. Ashton, 1962. Factors affecting the metabolizable energy content of poultry feeds. 5. The level of protein and of test material in the diets. 6. A note on relationship between digestible and metabolizable energy values. Poultry Sci.41:107-116.

Sibbald, I.R., and S.J. Slinger, 1963. A biological assay for metabolizable energy in poultry feed ingredients together with findings which demonstrate some of the problems associated with the evaluation of fats. Poultry Sci. 42:313-325.

Siegel, H.S., and G.W. Wood, 1964. Length of daily feeding time as an influence on growth and digestive efficiency in young chickens. Poultry Sci. 43:406-410.

Singsen, E.P., L.D. Matterson, A. Kozeff and L.D. Stinson, 1954. The effect of feeding high andlow-efficiency rations to growing pullets on their subsequent laying house performance. Poultry Sci. 33:1081.

Singsen, E.P., L.D. Matterson, J. Tlustohowicz and L.M.Potter, 1958. The effect of controlled feeding energy intake and type of diet on the performance of heavy type laying hens. Poultry Sci. 37:1243-1244.

Slinger, S.J., W.F. Pepper and J.D. Summers, 1964. Effect of debeaking and skip-feeding on the reproductive performance of meat strain breeder hens. Poultry Sci.43:1363.

Snedecor, G.W., and W.G. Cochran, 1968. Statistical methods 6th ed. Oxford and I.B.H. Publishing Co., Calcutta-16.

Strain, J.H., F.S. Gowe, F.D. Crawford, A.T. Hill, S.B.Slew and W.F. Mountain, 1965. Restricted feeding of growing pullets. 1. The effect on the performance traits of egg production stock. Poultry Sci. 44:701-716.

Summers, J.D., W.F. Pepper and E.T. Moran Jr., 1969. Restricting growth of broiler breeder pullets. Poultry Sci. 48:1121-1125.

Sunde, M.L., W.W. Cravens, H.R. Bird and J.G. Halpin,1954. The effect of complete and incomplete growing diets on subsequent performance of the laying hen. Poultry Sci. 33: 779-784.

Talapatra, S.K., S.C. Ray and K.C. Sen, 1940. The analysis of mineral constituents in biological materials. I. Estimation of phosphorous, chlorine, calcium, magnesium, sodium and potosium in food stuffs, Ind. J. Vet. Sci. & Anim. Husb. 10: 243-258.

Tanabe, Y., and Y. Tanaki, 1969. Effect of the limitation of feeding time on growth, sexual maturity and egg production of the meat-type chicken. Nutrition Abst. and Rev., (Abst. 4033) 39: 676.

Taylor, J.H., B.B. Bailey and J.H. Quisenberry, 1957. Comparison of certain pullet rearing and feeding programmes for egg production. Poultry Sci. 36:1162.

Treat, C.M., R.E. Davies, T.M. Ferguson and J.R. Couch, 1960. Effects of type of fat and various lipotropic agents on cholesterol distribution in chicks. Poultry Sci.39:1301.

Vaidya, S.V., 1971. Studies on the restricted feeding of White Leghorn pullets. M.V.Sc. & A.H. Thesis, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Voitle, R.A., H.R. Wilson and R.H. Harms, 1970. The effect of body weight restriction of broiler breeder pullets on subsequent performance. Poultry Sci. 49:1443.

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

Walter, E.D., and J.R. Aitken, 1961. Performance of laying hens subjected to restricted feeding during rearing and laying periods. Poultry Sci. 40:345-354.

Wolford, J.H., and D. Polin, 1971. Lipid accumulation in livers of adult S.C.W.L. females as influenced by feeding regimen. Poultry Sci. 50:1647.

Wolford, J.H., and D. Polin, 1972. Lipid accumulation and haemorrhage in livers of the laying chicken. A study on fatty liver haemorrhagic syndrome. Poultry Sci.51:1707-1713.

Wright, C.F., B.L. Damron, P.W. Waldroup and R.H. Harms, 1968. The performance of laying hens fed normal and low protein diets between 8-18 weeks of age. Poultry Sci. 47:636-638.

Yoshida, M., and H. Hoshii, 1969. Effect of restriction of feeding time of extremly high or low energy diets on the growth of chicks. Nutrition Abst. and Rev., (Abst.6044) 39:1006.

Yoshida, M., H. Hoshii and H. Morimoto, 1970. Studies on the grower diet for meat-types pullets 2. Effects of feeding diets extremly high and low in energy and protein levels and of alternative day feeding. Nutrition Abst. and Rev., (Abst. 4161) 40:722.

Zelenka, J., 1968. Influence of the age of chickens on the metabolizable energy values of poultry diets. Nutrition Abst. and Rev., (Abst. 8406) 38:1389.

Zlatkis, A., B. Zak and A.J. Boyle, 1953. A new method for the direct determination of serum cholesterol. J. Lab. Clin. Med. 41:486-492.