THE EFFECT OF THYROPROTEIN FEEDING ON EGG PRODUCTION, FERTILITY, AND HATCHABILITY OF BROILER BREEDING HENS

A Thesis

Presented to

The Faculty of Graduate Studies and Research

The University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Gerald A. Proverbs

March, 1971

ACKNOWLEDGEMENTS

The author is grateful to Dr. E. W. Stringham, Professor and Head, Department of Animal Science, University of Manitoba for making the facilities of the department available for the execution of this project.

Sincere gratitude is extended to Dr. D. B. Bragg for providing the opportunity to do this project. The author is indebted to Dr. L. D. Campbell, Assistant Professor of Poultry Science, for his invaluable guidance and constructive criticism during the writing of this thesis. The criticism and counsel of Dr. P. A. Kondra and Dr. J. Gavora is sincerely appreciated.

It is the author's desire to dedicate this dissertation in honour of his father and mother Harold and Nita Proverbs and to his wife Lesia for her forebearance and encouragement during neglect throughout this study.

This research could not have been conducted without the financial support which was provided by the National Research Council of Canada.

ABSTRACT

Five hundred and fifty two Hubbard hens (26 weeks of age) were used to study the effect of dietary thyroprotein on egg production, fertility, hatchability and other related parameters over seven consecutive 28-day periods. Four levels of thyroprotein were formulated and prepared to supply 0, 11, 22 and 44g per 100 kg of feed. The 11 and 22g levels were fed both throughout the laying cycle (periods 1 to 7) and during the latter part of the cycle (periods 4 to 7) while the 44g level was fed only during the latter part of the laying cycle. This resulted in six treatments with four replicates of 23 hens within each treatment.

Results indicated that egg production over the seven 28-day periods was improved significantly in those hens fed 11g of thyroprotein per 100 kg of feed. The thyroprotein-fed hens showed no significant difference in feed consumption or feed efficiency compared with controls. Both body weight gain and egg weight were significantly reduced, relative to that of controls, in those hens fed the higher levels of thyroprotein during the latter part of their laying cycle. Egg shell thickness and mortality remained unchanged irrespective of either dietary thyroprotein level or stage of the laying cycle at which it was fed.

Fertility was significantly reduced in the hens fed

22 and 44g thyroprotein per 100 kg of feed. In contrast, the semen of males fed dietary thyroprotein showed no significant difference in viability when compared with that of controls.

Hatchability of eggs of thyroprotein treated hens was significantly reduced in the first setting, when thyroprotein was fed from the start of the laying cycle. This reduction was only temporary, since hatchability returned to a level comparable with that of control for the remainder of the laying cycle, once the hens had become physiologically adjusted to the dietary thyroprotein. It was also observed that the eggs of the thyroprotein-fed hens required additional incubation time (24 hours). Thus, for increased egg production and normal fertility and hatchability rates in broiler breeding hens, the results show that thyroprotein should be fed at a level of 11g per 100 kg of feed and only after the hens have reached their peak production level.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

INTRODUCTION

It is the policy of commercial poultry producers to use two breeding flocks per year in their broiler breeder operations. Each breeding flock is kept in production for a six month period, at the end of which it is replaced with a younger flock. This is neither the most efficient nor most profitable system, but it is necessary because it becomes unprofitable to maintain a breeding flock once its egg production decreases below 50 percent. Since broiler breeders are fast growing and early maturing they tend to become obese by the time they are fifty weeks of age. Obesity it appears leads to decreased egg production of hens and poor mating performance of roosters.

With the advent of iodinated-proteins attention was focused on determining the influence of dietary iodinated-casein on egg production and egg quality of layer-type birds. There is considerable information available on the influence of iodinated-casein on layer type birds. However, information concerning the effects of this compound on the physiological activities of broiler type layers is limited.

Therefore the primary objective of this study was to examine the effect of dietary iodinated-casein on egg production in the broiler breeder and to investigate the influence of iodinated-casein on body weight, egg weight, and mortality.

Feed consumption, feed efficiency, egg shell quality, fertility and hatchability, as related to dietary levels of iodinated-casein, were also observed.

LITERATURE REVIEW

The Role of Thyroid Gland on Growth and Egg Production

Thyroidectomy in the hen reduces egg production (Winchester, 1939; Taylor and Burmester, 1940). The reduction is slight when thyroidectomy is incomplete and 70 to 80 percent when a completely hypothyroid individual is obtained. The first attempts to restore egg production to the preoperative level by thyroxine administration were not altogether successful (Winchester, 1939). Winchester and co-workers found that egg production was definitely dependent upon a relatively narrow range of concentrations of circulating thyroxine. Furthermore when thyroxine injection into thyroidectomized hens was interrupted, egg production declined to near zero, but returned to the control level when thyroxine was readministered at levels favourable to egg production. Although thyroxine is necessary for growth in the chicken it was found that thyroidectomized chicks attained nearly normal body size with thyroid replacement therapy through a range extending from far below normal glandular output to far above that level. However, body weight change was unaffected by the absence of the hormone (Winchester, Comar, and Davis, 1949; Winchester and Scarborough, 1953).

The Effect of Iodinated-Proteins on Egg Production

Crew and Huxley (1923) failed to observe any increase

in egg production in two groups of hens which were fed small quantities of desiccated thyroid for a period of four weeks. In a subsequent experiment Crew (1925) reported a remarkable "rejuvenesence" of seven hens and five cocks, 5 to 8 years of age, following the feeding of desiccated thyroid gland over a period of six months. The birds molted rapidly soon after the treatment was started and their new plumage was characteristic of younger fowls. The head furnishings became red and turgid and the low egg production, which was 7 eggs in six months previous to the experiment, was increased to 34 eggs in the same period of time. Cole and Hutt (1927) found no comparable stimulating effect on egg production when desiccated thyroid gland was fed to White Leghorn hens. Furthermore Asmundson and his associates found that when large amounts of desiccated thyroid were fed to laying hens a depression in egg production and body weight resulted (Asmundson, 1931; Asmundson and Pinsky, 1935). These observations would suggest that iodinated-protein feeding at optimal dosages might increase egg production especially in older hens.

Research regarding the role of thyroxine in egg production in the laying hen received a fresh stimulus with the development of iodinated-casein having the properties of natural thyroid protein by the action of iodine on casein in alkali solution (Reineke and Turner, 1942). Turner and

associates studied the possibility of using this compound in a continuous experiment lasting for six laying years. The results of their first experiment (Turner, Irwin and Reineke, 1945) which involved the use of small numbers of birds indicated that relative to controls, hens receiving 22g iodinated-casein per 100 kg feed had a greater yearly egg production record. They also found that the level of iodinated-casein per 100 kg feed was suboptimal while 44g seemed to be excessive. Thus Turner and co-workers deemed it advisable to feed diets supplemented with iodinated-casein to a larger number of birds so that they might investigate; firstly if the decline in egg production during the summer months could be retarded, secondly, the possible harmful effects of continuous iodinated-casein feeding; and thirdly, the effects on the rate of senescence.

An experiment was designed (Turner et al., 1945) in which 242 White Leghorn pullets were fed a diet supplemented with 22g iodinated-casein per 100 kg of feed for one year. Egg production of the experimental group was the same as that of the control group during the fall and winter months. However, after the first week in May, the control group gradually declined in production while the group on iodinated-casein continued to lay at the winter level until August, when egg production fell off very rapidly. The control group had a 44 percent decrease in production during the second

half of the year while the iodinated-casein-fed birds exhibited only a 6 percent reduction over this period. In fact over the three subsequent laying years hens receiving iodinated-casein at a 22g per 100 kg of feed level continued to lay at a considerably higher rate than did controls of the same age (Turner, Kempster, and Hall, 1946; Turner and Kempster, 1947, 1948). Actually in the last year reported, experimental hens in their sixth year of production averaged 119 eggs per bird compared to 35 for controls. Thus these experiments indicate that iodinated-casein supplemented at a low level may be used to prevent, in part, the yearly decline in egg production due to the senescent changes associated with increasing age as well as to maintain egg production during periods of hot weather when a decline in production parallels the seasonal decline in metabolism (Winchester, 1940).

Iodinated-casein seems to have different effects in different breeds of chickens. Rhode Island Red pullets showed a greater egg production during the summer months when fed 22g iodinated-casein per 100 kg feed than did controls (Turner et al., 1945). In contrast White Plymouth Rock hens which have a relatively low thyroid secretion rate (Schultze and Turner, 1945, as quoted by Blaxter et al., 1949) showed a similar increase in egg production which was maintained throughout the entire year rather than being

confined to the summer when fed an equal level of iodinated-casein (Turner, 1948).

Contrary to the results of Turner and his colleagues iodinated-casein failed to retard the normal decline in production after the first week in May (Hutt and Gowe, 1948). Furthermore these authors reported that there was no difference in production between the controls and the group of White Leghorn hens fed 22g iodinated-casein per 100 kg ration. Gutteridge and associates, in short term trials designed for purposes other than testing the efficacy of iodinated-casein to stimulated egg production, failed to show any influence of iodinated-casein on egg production (Gutteridge and Pratt, 1946; Gutteridge and Novikoff, 1947). Subsequently, similar results have been reported by other researchers (Godfrey, 1949; Lillie et al., 1952).

Detrimental effects of iodinated-casein feeding on egg production have also been reported (Berg and Bearse, 1951). They found that feeding 34g iodinated-casein per 100 kg ration, caused a marked depression (22%) in the rate of lay in White Leghorn hens. Similarly other workers have found that egg production in layers was significantly reduced below their controls when fed iodinated-casein at a level of 22g per 100 kg feed (Hoffman and Wheeler, 1948; Savage et al., 1952; Oloufa, 1953).

The Effect of Iodinated-Proteins on Egg Weight

The influence of the thyroid on egg weight has been studied and it appears that there is some discrepancy with regard to its effect. Hyperthyroidism caused a decline in egg size (Asmundson, 1931; Asmundson and Pinsky, 1935; Wilson, 1949). They also reported that egg production ceased in many of the smaller birds because equivalent amounts of thyroid tissue would produce a greater hyperthyroid condition in these birds. Furthermore they noted that the yolk size decreased but the albumen was unaffected under hyperthyroid conditions and it was concluded that this effect was due to a reduction in growth rate of the ovum rather than physiological malnutrition. However, Crew and Huxley (1923) using small doses of desiccated thyroid, did not observe such an effect. A similar lack of response was obtained when birds were fed 22g iodinated-casein per 100 kg feed (Turner et al., 1945a, b, 1946; Hutt and Gowe, 1948; Hoffmann and Wheeler, 1948a; Turner, 1948). Thus it would appear that this effect on egg weight is only apparent at high treatment levels.

It has been shown that high environmental temperatures cause a decline in egg shell thickness (Warren and Schnepel, 1940). Furthermore desiccated thyroid feeding to produce a hyperthyroid condition was observed to increase egg shell weight (Asmundson, 1931; Asmundson and Pinsky,

1935). Similarly Gutteridge and Pratt (1946), Gutteridge and Novikoff (1947) measured the specific gravity of eggs and found that during the summer months the egg shells of hens fed iodinated-casein were significantly stronger than those of the controls. Hoffmann and Wheeler (1948) reported that the egg shells of Rhode Island Red pullets fed 22g iodinated-casein per 100 kg feed from June to October were significantly stronger than those of the controls. This response was accompanied by a loss in body weight in the birds receiving iodinated-casein. Such an improvement in egg shell thickness together with a reduction in body weight was also observed by Berg and Bearse (1951), and Lillie et al., (1952). Oloufa (1953) reported that birds on iodinated-casein supplemented diets produced eggs with thicker shells than those of controls, but the hens did not sustain a loss in body weight. Thus, the majority of evidence indicates that the decline in shell weight and strength characteristic of the end of the laying season and during periods of high environmental temperature might be counteracted by feeding iodinated-casein.

Perhaps the loss of body weight in those birds maintained on an iodinated-casein supplemented ration was due to a reduced feed consumption. Actually it has been reported that iodinated-protein feeding causes a reduction in feed intake (Asmundson and Pinsky, 1935). Iodinated-casein

also appears to exhibit an effect on the efficiency of feed utilization (Wheeler, Hoffmann and Graham, 1948; Berg and Bearse, 1951). Wheeler and co-workers reported that Rhode Island Red birds, fed iodinated-casein, used feed more efficiently than did controls during the first six weeks on trial as shown by the more rapid rate of growth. However, over the full twelve week study period, the treated birds were no more efficient than were the controls. Godfrey (1949) confirmed that feed efficiency in laying hens was not affected by feeding iodinated-casein. Furthermore he also reported that body weight was unaffected in the birds fed iodinated-casein. It is possible that the inconsistency of the results of various experimenters may be explained on the basis that adipose tissue deposition may be affected differently in different strains of birds.

There was no demonstrable effect of iodinated-casein on the mortality of the hens involved in the series of experiments conducted by Turner's group at Missouri (Turner et al., 1945a, b, 1946; Turner and Kempster, 1947, 1948). The validity of the results can be questioned due to the small number of birds included in this study. However, similar investigations, using much larger numbers of birds, showed that the mortality of groups consuming iodinated-casein at levels from 11g to 44g per 100 kg feed was not significantly different from that of controls (Hutt and Gowe,

1948; Berg and Bearse, 1951; Oloufa, 1953). Furthermore the fact that these experiments were not all conducted in the same season lends credence to the idea of little or no effect of normal dietary levels of iodinated-casein on mortality in laying hens.

The Effect of Iodinated-Proteins on Reproduction

Seasonal influence on semen production in roosters has been thoroughly studied. The greatest volume of semen is produced in the period from November to March (Wheeler and Andrews, 1943). Andrews and Schnetzler (1946) found that thiouracil in the diet at levels as high as 0.2 percent and fed between the sixth and fourteenth weeks slightly reduced the size of the testes. Shaffner and Andrews (1948) reported that neither sperm concentration nor total number of spermatozoa was affected by feeding roosters 0.2 percent thiouracil. However, the inclusion of thiouracil in the diet caused a significant reduction in actual fertility; as a result they concluded that the gonads of thiouracil treated males were incapable of producing spermatozoa that were sufficiently viable to survive a normal length of time in the oviduct of the hen. Therefore it was reasoned that since thiouracil feeding lowers the quality and/or quantity of semen produced by treated cocks, then iodinated-casein feeding might have the opposite effect on rooster semen.

Shaffner (1948) fed a group of two-year-old Barred Rock roosters 22g iodinated-casein per 100 kg feed for a four month period and found that there was little or no effect on the volume or concentration of semen, but there was a definite reduction in semen quality as evaluated by actual fertility-tests. These tests showed that the males had a score or 91.5 percent but this was reduced to 61.3 percent with the incorporation of iodinated-casein into their diet.

Contrary to the results obtained by Shaffner (1948), Huston and Wheeler (1949) reported that feeding iodinated-casein at the same level (22g per 100 kg feed) to mature Rhode Island Red cocks, did not decrease semen quality nor did it prevent the seasonal decline in semen production as determined by natural mating tests. However, in pullets fed iodinated-casein during the growing period, the onset of egg production was retarded from the 20th to the 25th week (Wheeler and Hoffmann, 1948a). They also found that testes weights of cockerels on the same treatment was increased. This would suggest that iodinated-casein retards gonad development in hens but not in roosters.

Wheeler and Hoffmann (1948b) also reported that in pullets fed iodinated-casein (44g per 100 kg feed) from the day of hatching the fertility of eggs laid was unchanged but the fecundity was significantly increased above that of control birds. At first it appeared that hatchability was

less in the group fed iodinated-casein. However, if the incubation period of eggs from this group was prolonged, hatchability was comparable with that of the controls. In fact the eggs of iodinated-casein fed birds required 12.3 hours' more incubation time than those of the control birds (McCartney and Shaffner, 1949).

The chicks from the iodinated-casein treated hens had enlarged thyroids (Wheeler and Hoffmann, 1948b). This phenomenon has been noted by McCartney and Shaffner (1949) and Godfrey (1949). It is generally believed that the chicks from hyperthyroid hens are themselves hypothyroid. The thyroid size is reduced to normal, however, after 15 days on a standard diet (Wheeler and Hoffmann, 1948b).

EXPERIMENTAL PROCEDURE

An experiment was designed to study the effect of thyroprotein (iodinated-casein) on egg production, egg weight, feed efficiency, fertility and hatchability. Five hundred and fifty two Hubbard breeding hens (22 weeks of age) were randomly allotted into twenty four pens (5 ft. x 12 ft.) of twenty three birds each. Subsequent to the beginning of the experiment the hens were fed a basal breeder diet (Table I) for a four week adjustment period. Two cockerels, selected at random, were placed in each pen at the start of the adjustment period. Throughout the experiment males were replaced with spares whenever they became lame, lost body weight or if there was repeated fighting between the two males in the same pen. Both water and feed were supplied ad libitum during this period and for the extent of the experiment.

On termination of the adjustment period, the twenty four pens of hens were divided at random into six experimental treatments (4 replicates per treatment). At this time six dietary treatments which consisted of a control and three levels of thyroprotein fed for different intervals of time were randomly assigned to the six groups. Subsequent to the adjustment period, the experiment was conducted for seven 28-day periods and terminated when the birds were

TABLE I. Composition of Basal Diet[1,2] (Diet 1)

Ingredients	Amount (%)
Wheat (13% PROTEIN)	71.0
Soybean meal (44% PROTEIN)	13.0
Fish meal (70% PROTEIN)	2.0
Alfalfa meal (17% PROTEIN)	2.0
Animal tallow	3.0
Limestone	5.0
Rock phosphate	2.5
Vitamin premix[3]	1.0
Mineral premix[4]	0.5

[1]Calculated analysis of ration: Crude protein, 16.70%; Crude fibre, 4.32%; Metabolizable Energy (kcal/kg) 2795; Methionine, 0.32%; Lysine, 0.83%; Calcium, 3.01%; Phosphorous, 0.77%.

[2]Diets 2, 3, and 4 were formulated by incorporating respectively 11, 22 and 44g of thyroprotein into 100 kg of basal diet.

[3]Vitamin premix supplied the following per kilogram of ration: Vitamin A, 7313 I.U.; Vitamin D_3, 837 I.C.U.; Vitamin E, 11 mg; Vitamin B_{12}, 11 mcg; Choline, 112.5 mg; Riboflavin, 2.25 mg; Niacin, 6.75 mg; Pantothenic acid, 4.5 mg; Methionine, 50g; Santoquin, 25g.

[4]Mineral premix supplied the following per kilogram of ration: Manganese, 81.4 mg; Zinc, 44 mg; Sodium Chloride, 4.8g.

fifty four weeks of age.

The dietary treatment groups and interval of thyroprotein feeding were as follows:

Treatment I - basal diet (diet 1) from twenty six weeks of age to the end of the experiment (seven 28-day periods).

Treatment II - diet 2, containing 11g thyroprotein per 100 kg, for the seven 28-day experimental periods.

Treatment III - diet 3, containing 22g thyroprotein per 100 kg, for the seven 28-day experimental periods.

Treatment IV - diet 1 from 26 to 38 weeks of age (three 28-day periods) at which time diet 1 was replaced with diet 2 for the remaining four 28-day periods.

Treatment V - diet 1 from 26 to 38 weeks of age when diet 3 was substituted for diet 1 for the last four 28-day periods.

Treatment VI - diet 1 for the first three 28-day periods at which time diet 4 (44g thyroprotein per 100 kg) replaced the basal diet for the remaining four 28-day periods.

The thyroprotein was incorporated into the basal

diet by premixing the iodinated-casein with wheat middlings at the rate of 11 grams to 1 kilogram wheat middlings. This premix was then incorporated into the basal breeder diet at the expense of wheat (Table I) in the appropriate quantities to supply the desired levels of thyroprotein in the experimental diets.

The hens were weighed at the beginning and end of the adjustment period and during the experiment forty hens were randomly selected from each group (10 per replicate) and weighed at the end of each period. Egg production and mortality were recorded daily, and any dead birds were taken to the Provincial Veterinary Laboratory for a post-mortem autopsy to ascertain the cause of death. Daily feed consumption (g feed/hen/day), egg production (%) and mortality were calculated for each period. Feed efficiency as measured by grams of feed required to produce one egg was calculated for each experimental period.

Fertility (%) and hatchability (% of fertile eggs) were calculated for each period except the second one. Eggs for incubation were collected for at least three consecutive days within each period and stored for five days in a cooler at 10 C until they were incubated. Before traying the eggs, they were individually candled and those with a crack or an incorrectly located air-sac were rejected. Hence, the soundest thirty eggs from each replicate were selected, weighed as

a group and then put in the incubator trays. The eggs were allowed to warm up to room temperature before being placed inside the incubator, where they remained for 19 days. On day 20 the eggs were removed and candled. At this time all eggs showing no development and those containing dead embryos were separated from the eggs with live embryos. All live embryos were transferred to hatching trays and placed in the hatcher until the 22nd day. The eggs without embryo development and those containing dead embryos were broken out as a precautionary check for infertility and to examine the dead embryos for any morphological abnormalities. On the 22nd day the chicks which had hatched were counted and removed while the unhatched eggs were broken out and a macroscopic examination of the dead embryos was conducted.

Egg shell thickness for a total of 240 eggs was measured during the fourth and seventh periods (20 eggs per group per period). For the measurement to be made, five eggs were randomly selected from each replicate, broken and the shells washed and dried. The thickness of the shell was then measured with an Ames micrometer.

On account of the repeated variability in fertility with natural matings, it was decided to carry out an additional fertility study with the Hubbard hens and roosters. Thus a two-way reciprocal cross involving White Leghorn cocks and hens (De Kalb strain) as the other group was set

up. The objective of this study was to determine if thyroprotein feeding over the previous seven 28-day periods had had any ill effects on the gonads of the Hubbard birds.

When the egg production study was terminated, the roosters were removed from the pens and each hen in the six experimental treatments was examined to determine its production status. The hens having the least amount of depot fat in the abdomen, as well as the greatest distance between pubic bones, and with a moist and smooth vent were judged to be the ones laying most frequently. Finally ten hens were selected from each of the six treatments for the fertility study. Each treatment was maintained on its original diet from the previous study. An adjustment period was allowed during which a daily egg production record was kept. In the course of this period one hen was removed from treatment I because it went into a molt two days after the study was set up. Furthermore, it was discovered that a hen in treatment VI was laying eggs with twin yolks. The hen responsible was determined by the use of trap nests and was removed from the pen. Thus, for the fertility study, where the effect on the Hubbard females was being determined, all treatments had ten hens except treatments I and VI which had nine hens per treatment. In addition forty White Leghorn hens, to be used to check the fertility of the Hubbard males, were kept in pairs in community cages and fed a standard layer diet.

The Hubbard males which had been separated from the females were segregated into four groups according to their previous diets and placed in separate pens. The lighting in the pens was reduced to near zero for a 10-day period to minimize fighting. At the end of the 10-day period, the lighting duration was returned to normal (14 hours per day). Those roosters which were in poor condition were removed and the remaining healthy ones trained for collection of semen (Burrows and Quinn, 1937). In addition a group of twelve White Leghorn cocks (De Kalb strain) was trained simultaneously.

Semen was collected from the twelve White Leghorn roosters and pooled prior to intravaginal insemination of the six groups of Hubbard hens. Similarly semen was collected and pooled from six to ten Hubbard cocks per group. It was necessary to collect semen from this many Hubbard roosters because the volume of semen produced by each male on stimulation differed considerably. The pooled semen from each of the four respective groups of cocks was used to inseminate ten White Leghorn hens intravaginally. Every hen was artificially inseminated with 0.05 ml semen.

Insemination of the Hubbard hens was carried out one day while the White Leghorn hens were inseminated on the following day. Semen was collected from the males beginning at 15.00 hours and intravaginal insemination was completed

within 45 minutes of collection of the first ejaculate. Both the Hubbard and White Leghorn hens were inseminated for a second time nine days after the initial insemination.

Eggs were collected for seven consecutive days after each insemination. The eggs collected were candled prior to being incubated. These eggs were incubated for six days since embryo development is readily detectable then. At the end of the incubation period the eggs were removed and candled to determine fertility (%). Those that appeared clear in candling were broken out to determine if they were infertile or early dead. The fertility (%) of each group of Hubbard hens and White Leghorn hens was then calculated.

Data were tested by analysis of variance as described by Snedecor (1956) and multiple range comparisons were made according to Duncan (1955). The data (%) calculated for egg production, mortality, fertility, and hatchability were transformed using arcsine before being subjected to analysis of variance. Furthermore multiple range comparisons were made on the transformed data; however, the means reported in the respective tables are the retransformed values.

RESULTS AND DISCUSSION

Egg Production

The effect of dietary thyroprotein on egg production of broiler breeding hens is illustrated for the various treatments as; average hen day production values for each replicate in Appendix Table 1, average values of four replicates except treatment V, in which only three replicates were considered, for each period in figures 1 and 2, and averaged over all seven periods in Table II. The statistical analysis of these data is presented in Appendix Table 2.

The results indicate that some of the hens fed thyroprotein laid at a higher level than that of the controls (treatment I). The production rate for treatments II and IV over the seven 28-day periods was 63.3% which was significantly higher ($P < 0.05$) than that in treatment I (59.7%) and treatment VI (60.1%). Thus, from the evidence presented here it appears that thyroprotein feeding at a low level (11g per 100 kg of feed) enhances egg production in broiler breeding hens. These results corroborate those of Turner (1948c) and Turner *et al.* (1945a, b, 1946, 1947, 1948), and dispute those of Wheeler and Hoffmann (1948), Hutt and Gowe (1948), and Berg and Bearse (1951).

Although the hens fed diet 3 (22g thyroprotein per 100 kg) showed a trend toward increased egg production, the

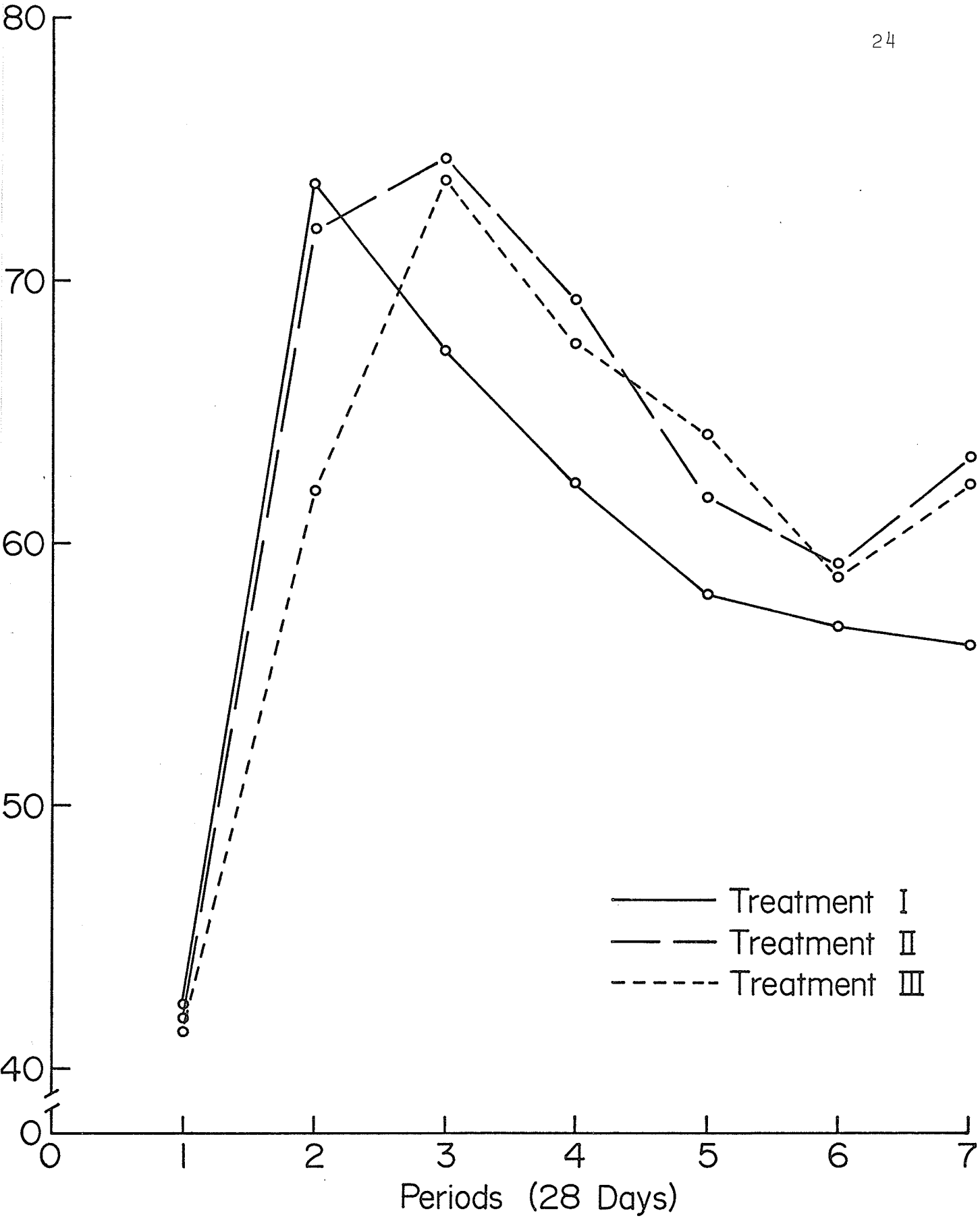
TABLE II. Effect of level and interval of thyroprotein feeding on egg production of broiler breeding hens

Treatment[1]	Level of Thyroprotein in Diet (g)	Hen Day[2,3] Production (%)
I (diet 1)	0	59.7^{ac}
II (diet 2)	11	63.3^{b}
III (diet 3)	22	61.7^{bc}
IV (diet 2)	11	63.3^{b}
V (diet 3)	22	62.0^{bc}
VI (diet 4)	44	60.1^{ac}

[1]The birds in treatments I, II, and III were fed the respective diets for the entire experiment (seven 28-day periods) while those in treatments IV, V and VI were fed diet 1 for the first three 28-day periods and the diets indicated for the remaining four 28-day periods.

[2]Means not having the same superscript are significantly different ($P < 0.05$).

[3]Statistical analysis of data was performed after arcsine transformation of original data.



1 Egg Production of Hens Fed Thyroprotein (periods 1 to 7)

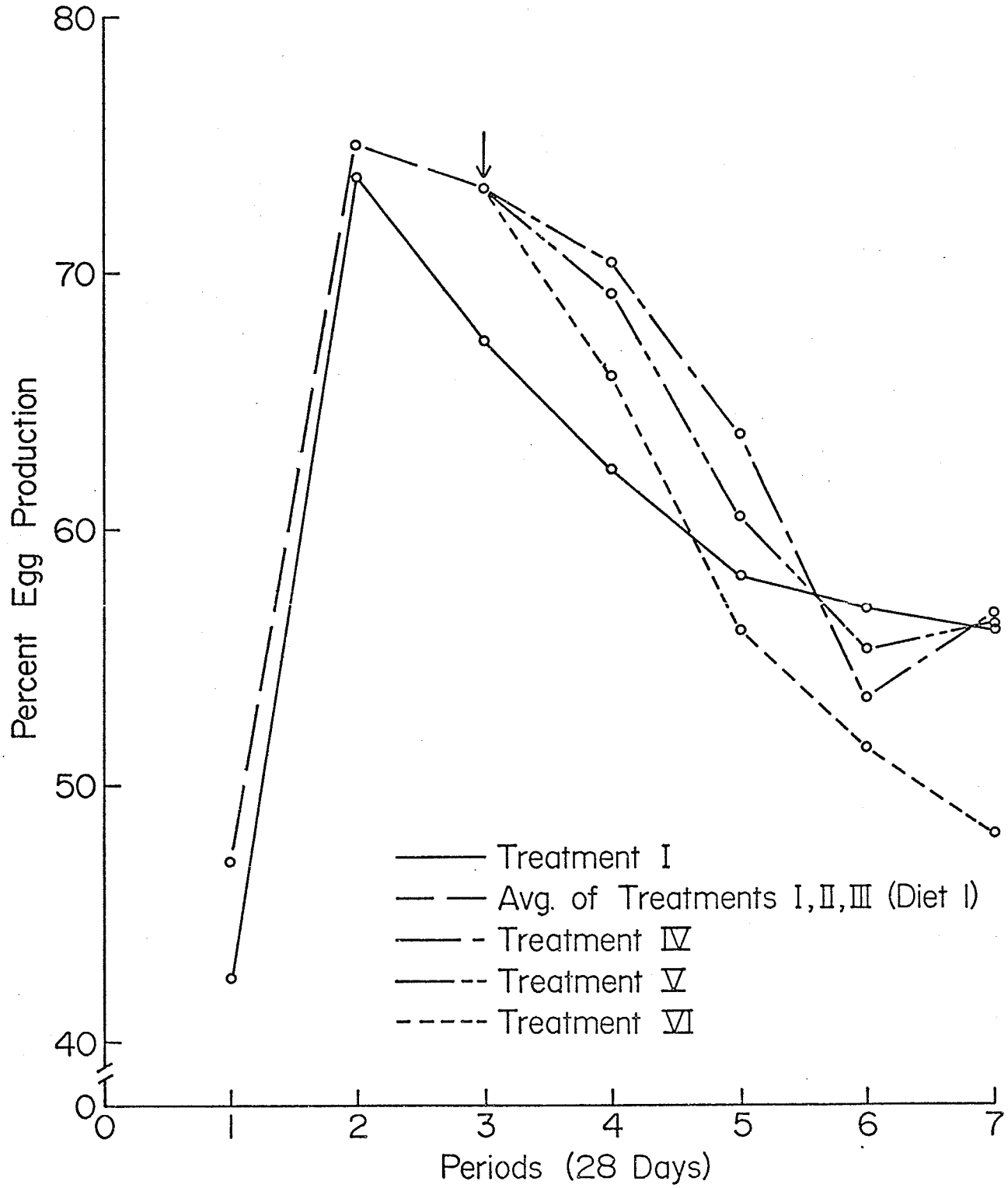


Fig. 2 Egg Production of Hens Fed Thyroprotein (periods 4 to 7)

levels of production in treatments III and V were not significantly higher than that of the control. Furthermore, the results show that thyroprotein has a similar effect when supplementation is started either at the beginning of production or after peak production. However, in comparison with the hens fed thyroprotein throughout the entire laying cycle, it appears that there is a trend toward an increased rate of decline in egg productions of the hens in which the feeding of thyroprotein is initiated during the latter stages of the laying cycle.

It has been established that egg production is primarily a function of gonadotrophic hormone production and the accompanying ovarian hormones acting upon the oviduct (Turner et al., 1945b). Many factors in turn influence the secretion of the gonadotrophic hormone. Of the endocrine glands, the thyroid may be the most important in influencing the secretion of gonadotrophins, since it is believed that the thyroid hormone directly or indirectly stimulates the pituitary to secrete more of the gonadotrophic hormone. In turn the gonadotrophic hormone stimulates ovum and yolk secretion and hence increases egg production (Turner and Kempster, 1948). Furthermore, these researchers have postulated that thyroprotein feeding in birds causes the thyroid gland to cease thyroid hormone (thyroxine) secretion, which would result in almost complete cessation of

thyrotrophic hormone secretion by the anterior lobe of the pituitary. It has been further suggested (Turner, 1948c; Irwin et al., 1943) that in the absence of thyrotrophic hormone secretion, the basophilic cells of the anterior pituitary may produce a greater amount of gonadotrophic hormone and thereby increase egg production as stated above.

Irrespective of the exact mode of action of dietary thyroxine (thyroprotein) the efficacy of this treatment would appear to be related to the inherent ability of the thyroid of the hens to secrete thyroxine. In other words, the rate of thyroid hormone secretion could be a major limiting factor in the production of eggs, especially in certain breeds and strains of fowl with limited egg producing capacity (Schultze and Turner, 1945 as reported by Turner, 1948c). This would appear to be especially true for broiler breeding hens since egg production has been sacrificed in the selection process due to the physiological antagonism of egg production and high meat yield.

The variable results reported in the literature with regard to the effect of thyroprotein on egg production may be due, in part to the genetic variability of different breeds and strains in the level of thyroxine secretion. In those breeds and strains which have the ability to maintain high uniform egg production throughout the year, it would appear that their thyroids have the capacity to continue

hormone secretion at a level adequate for high egg production. In such birds, the feeding of thyroprotein would have little if any beneficial effect. Whereas in those breeds with limited egg producing capacity it is possible to increase egg production within limits by feeding thyroprotein as exemplified in this study.

The present investigation has demonstrated the value of feeding thyroprotein to a naturally low egg producing breed of fowl (Hubbard hens). In this case the egg production of the hens fed thyroprotein, at a level of 11g per 100 kg of feed, continued at a higher level for the entire experiment. Poultry producers who operate broiler breeding farms stand to benefit from feeding thyroprotein at the above mentioned level to their breeding flocks during their growing period. Since thyroprotein not only increases egg production, but it has also been shown to retard the onset of production from the 20th to 25th week. These are two keenly desired assets for broiler breeding operations in order to realize maximum profits.

Feed Consumption, Feed Efficiency and Body Weight Gain

The effect of dietary thyroprotein on feed consumption of broiler breeding hens is illustrated in Table III. These results show that each bird in treatment VI (diet 4) consumed 33.7 kg of feed for the entire experiment (seven 28-day periods) while the birds in the control group consumed

TABLE III. Effect of level and interval of thyroprotein feeding on feed consumption, feed efficiency and body weight gain of broiler breeding hens

Treatment[1]	Level of Thyroprotein in Diet (g)	Feed Intake[2] (kg)	Feed (g) / Egg	Feed (kg) / Dozen Eggs	Body Weight[2,3] Gain (g)
I (diet 1)	0	34.7	306.3	3.7	849.0[a]
II (diet 2)	11	35.1	291.8	3.5	740.0[a]
III (diet 3)	22	34.9	294.2	3.5	726.4[a]
IV (diet 2)	11	35.1	284.3	3.4	767.3[a]
V (diet 3)	22	34.8	293.6	3.5	503.9[b]
VI (diet 4)	44	33.7	299.2	3.6	444.9[b]

[1]The birds in treatments I, II, and III were fed the respective diets for the entire experiment (seven 28-day periods) while those in treatments IV, V, and VI were fed diet 1 for the first three 28-day periods and the diets indicated for the remaining four 28-day periods.

[2]Data for feed intake and body weight gain per bird are the average of four replicates for each treatment over seven 28-day periods.

[3]Means not having the same superscript are significantly different ($P < 0.05$).

on the average 34.7 kg of feed. The average consumption per bird for all other treatments was slightly greater than that of the controls. However, none of the differences were statistically significant. On the other hand, if feed consumption is examined for the six treatments on a period by period basis a trend toward reduced feed intake becomes apparent for the birds fed thyroprotein supplemented diets (Appendix Table 3). In the first period when birds in treatments II and III were fed thyroprotein, there was a marked, but non-significant, decrease in feed intake compared with that of controls. This trend continued throughout period 2, but during periods 3 to 7 the birds in these two treatments consumed slightly more feed than the controls.

In addition these birds maintained a slightly higher level of feed consumption for the remaining four 28-day periods so that in the overall, the hens in treatments II and III consumed 35.1 kg and 34.9 kg per hen respectively which was similar to that of the controls (34.7 kg). Similarly, when diets 2, 3, and 4 were fed to birds in treatments IV, V, and VI respectively at the start of period 4, there was a non-significant reduction in the amount of feed consumed during period 4. However, by the end of period 5 feed intake in these three treatments returned to a level comparable to that prior to thyroprotein feeding. Thus it seems that incorporation of thyroprotein into the diet

results in decreased feed intake during the first few weeks of feeding. However, once the hens have become physiologically adjusted to the thyroprotein diets, they return to a feed consumption level comparable to hens fed a standard breeder diet.

These results are not entirely in agreement with those published by Berg and Bearse (1951) who stated that feeding thyroprotein at a level of 22g per 100 kg feed caused a significant decrease in feed consumption. However, these authors reported that after five weeks on the diet, the birds had adjusted to the thyroprotein and showed an increase in feed intake so that by the end of the experiment they were consuming as much as they had in the period prior to the experiment. The latter statement verifies the observation made in this study. This trend toward reduced feed intake during the initial stages of thyroprotein feeding has not always been observed as Godfrey (1949) found that thyroprotein in the diet of New Hampshire pullets produced no effect whatsoever on feed consumption.

The efficiency of feed utilization (g feed to egg ratio) appeared to have been improved in all treatments fed thyroprotein when compared with the control (Table III). However, this improvement in feed utilization was not statistically significant. The hens in treatments IV and V (diet 2 and 3, respectively, from period 4) utilized feed as

efficiently as those in treatments II and III (diet 2 and 3, respectively, from period 1). Thus the efficiency of feed utilization was not affected by the age of the hens.

A summary of the data for body weight gain, presented in Table III, indicates that thyroprotein feeding had a detrimental effect on body weight gain of the hens in treatments V and VI. Hens in treatment V gained 503.9g over the seven 28-day periods while those in treatment VI gained 444.9g over the same period in comparison with a weight gain of 849.0g for the controls. It is of interest to note that this effect of a decrease in weight gain evident for treatment V was not noticed when the thyroprotein (22g per 100 kg of feed) was fed from the beginning of the experiment (treatment III).

When the data obtained were separated as to weight gain over the first three 28-day periods and weight gain over the last four 28-day periods, the relation between dietary level of thyroprotein and body weight gain becomes clearer (Table IV). Hens in treatment III (diet 3) gained significantly ($P < 0.05$) less weight (267.9g) over the first three 28-day periods when compared with those of treatment I (control) or treatment II (diet 2) which gained 485.8g and 426.8g respectively. However, the hens in treatment III gained more weight than the controls during the last four periods, but did not differ significantly from that of controls.

TABLE IV. Effect of level and interval of thyroprotein feeding on body weight gain of broiler breeding hens

Treatment[1]	Level of Thyroprotein in Diet (g)	Weight gain (g)[2,3]	
		Period 1 to 3	Period 4 to 7
I (diet 1)	0	485.8[a]	372.3[A]
II (diet 2)	11	426.8[ab]	381.4[A]
III (diet 3)	22	267.9[b]	463.1[A]
IV (diet 2)	11	531.4[a]	349.6[A]
V (diet 3)	22	494.9[a]	68.1[B]
VI (diet 4)	44	458.5[a]	49.9[B]

[1]The birds in treatments I, II, and III were fed the respective diets for the entire experiment (seven 28-day periods) while those in treatments IV, V, and VI were fed diet 1 for the first three 28-day periods and the diets indicated for the remaining four 28-day periods.

[2]Means not having the same superscript are significantly different ($P < 0.05$).

[3]Means not having the same superscript are significantly different ($P < 0.01$).

It is of interest to note the little amount of weight gained over the final four 28-day periods by the hens in treatments V and VI. Those in treatment V gained 68.1g while those in treatment VI gained 49.9g in comparison with a gain of 350g or greater for the hens in the other treatments.

It appears from the results as if the level of 22g thyroprotein per 100 kg of feed is physiologically harmful to the hen since it caused a reduction in growth rate. However, the results show that younger birds fed this level are able to adjust to the diet and regain a normal growth rate. It seems that the older hens cannot adjust to an equivalent level of thyroprotein consequently the marked reduction in weight gain. Similar results were obtained by Hoffmann and Wheeler (1948), and Berg and Bearse (1951) when they fed 22g of thyroprotein per 100 kg of feed to laying hens.

Egg Weight and Thickness of Egg Shell

Level of dietary thyroprotein and more significantly the interval of time when the thyroprotein was fed to broiler breeding hens influenced the weight of the eggs laid (Table V). Eggs laid by hens in treatments II and III weighed 64.3 and 64.8g, respectively and did not differ significantly in weight from those laid by the control hens (treatment I) which weighed 64.7g. Similarly the eggs produced by hens in treatment IV were of a similar weight (64.4g) to those of

TABLE V. Effect of level and interval of thyroprotein feeding on egg weight and egg shell thickness of broiler breeding hens

Treatment[1]	Level of Thyroprotein in Diet (g)	Egg Weight[2] (g)	Egg Shell Thickness (mm)
I (diet 1)	0	64.7[a]	0.350
II (diet 2)	11	64.3[ab]	0.355
III (diet 3)	22	64.8[a]	0.358
IV (diet 2)	11	64.4[ab]	0.350
V (diet 3)	22	63.3[c]	0.353
VI (diet 4)	44	63.7[bc]	0.348

[1]The birds in treatments I, II, and III were fed the respective diets for the entire experiment (seven 28-day periods) while those in treatments IV, V, and VI were fed diet 1 for the first three 28-day periods and the diets indicated for the remaining four 28-day periods.

[2]Means not having the same superscript are significantly different ($P < 0.05$).

control hens. However, the average weights of the eggs laid by hens in treatments V and VI (63.3 and 63.7g respectively), although not differing significantly from each other were significantly ($P < 0.05$) lighter than that of control eggs. Thus it appears that the higher levels (greater than 11g per 100 kg of feed) of dietary thyroprotein have a detrimental effect on egg weight when fed to broiler breeding hens. For a dietary level of 22g thyroprotein per 100 kg of feed the effect becomes expressed only when the hens are fed thyroprotein after they have reached maximum egg production. Whether or not this applies for the higher level (44g) of thyroprotein cannot be ascertained from the present data.

The results of the present experiment indicate that thyroprotein feeding has no effect on egg weight when fed at low levels (11g per 100 kg of feed) is in agreement with the data reported by Hutt and Gowe (1948). Actually, these researchers found that in one trial eggs laid by thyroprotein-fed hens were heavier than those of the controls; however the difference was not significant. Similarly the reduction in egg size with the higher levels of thyroprotein feeding is consistent with the information available in the literature. Asmundson (1931) and Asmundson and Pinsky (1935) using high levels of desiccated thyroid and Berg and Bearse (1951) using thyroprotein at 22g per 100 kg of feed reported reductions in egg size relative to controls when these substances

were included in the diet of broiler hens. The former research workers were able to demonstrate that a diminished yolk size due to a reduction in the rate of growth of the ovum was associated with the hyperthyroid condition produced by the desiccated thyroid treatment. A similar response may have produced the reduced egg weights noticed in the present investigation. The reason why the effect was more pronounced when thyroprotein was fed at the beginning of the fourth period rather than at the beginning of the experiment is not clear, but may be related to the relative degree of hyperthyroidism produced at the two different time intervals.

Table V shows the thickness of egg shells of eggs laid by hens in the six experimental treatments. The shell thickness of the eggs of hens fed thyroprotein from the start of the experiment were no different from those of the hens fed thyroprotein from the 4th to 7th periods and neither of these differed from the shell thickness of the control eggs. The thickness of egg shells ranged from 0.348 mm to 0.358 mm. These results are in accord with those published by Hutt and Gowe (1948), but are in disagreement with those reported by Gutteridge and associates (Gutteridge and Pratt, 1946; Gutteridge and Novikoff, 1947), and Berg and Bearse (1951). It is possible, although yet unproven, that the inconsistency of the results of different researchers may be explained on the basis that strains of chickens of differing

thyroid gland activity levels were utilized in the various experiments.

Mortality

The effect of dietary thyroprotein on the mortality rate of broiler breeding hens is presented in Table VI. Mortality rates in the six experimental treatments varied from 12 to 20.7%, with no significant differences among treatments. These results lend support to the suggestion that the degree of hyperthyroidism produced by feeding 22g thyroprotein per 100 kg of feed is so mild in character that glands and organs other than the thyroid are not overstimulated (Turner, 1948). In fact, it seems from the present data that this hypothesis can be extended to include a level of 44g per 100 kg of feed. Therefore it appears from the results reported herein and from those reported by other researchers (Turner et al., 1945a, b, 1946, 1947; Turner, 1948; Hoffmann and Wheeler, 1948) that thyroprotein at levels up to and including 44g per 100 kg of feed can be fed to broiler breeding hens either at the initiation of egg production or after the hens have reached maximum production without any detrimental effects on health or survival.

Fertility and Hatchability

Due to the variability in the numbers of fertile eggs obtained with natural matings in the six treatments,

TABLE VI. Effect of level and interval of thyroprotein feeding on the mortality of broiler breeding hens

Treatment[1]	Level of thyroprotein (g)	Mortality[2] (%)
I (diet 1)	0	16.3
II (diet 2)	11	20.7
III (diet 3)	22	14.1
IV (diet 2)	11	12.0
V (diet 3)	22	13.0
VI (diet 4)	44	18.5

[1]The birds in treatments I, II, and III were fed the respective diets for the entire experiment (seven 28-day periods) while those in treatments IV, V, and VI were fed diet 1 for the first three 28-day periods and the diets indicated for the remaining four 28-day periods.

[2]Statistical analysis of data was performed after arcsine transformation of original data.

the fertility results obtained for each of the six periods were considered relatively unreliable. Furthermore it was not possible to make legitimate comparisons between treatments since the fertility of treatment I (controls) was decidedly below that expected for meat-type birds. The variable and low level of fertility obtained in all of the treatments may have been due, in part, to poor rooster performance.

The fertility results obtained with artificial insemination, presented in Table VII, indicate that the level at which thyroprotein was fed does affect fertility. With artificial insemination, the fertility of the eggs laid by the control hens (treatment I) was markedly improved (78% in comparison with 70% or less with natural matings). The fertility of eggs from treatments II and IV were not significantly ($P < 0.05$) different from that of treatment I, whereas the fertility of eggs in treatments III and V (59.0% and 67.0% respectively), although not significantly different from each other, were significantly ($P < 0.05$) lower than those for hens in treatments I, II, and IV. The high fertility (71.0%) of the eggs in treatment VI relative to treatment III, cannot be explained.

These results suggest that thyroprotein fed at a level of 22g per 100 kg of feed has a depressing effect on fertility in the broiler hens. This is contrary to the

TABLE VII. Effect of interval of thyroprotein feeding on fertility and hatchability of eggs of broiler breeding hens

Treatment[1]	Level of Thyroprotein in Diet (g)	Fertility[2,3] (%)	Hatchability[4] (%)
I (diet 1)	0	77.8[a]	80.8
II (diet 2)	11	77.5[ab]	88.6
III (diet 3)	22	59.0[d]	85.3
IV (diet 2)	11	79.6[ab]	83.5
V (diet 3)	22	67.0[cd]	89.7
VI (diet 4)	44	71.0[bc]	80.2

[1]The birds in treatments I, II, and III were fed the respective diets for the entire experiment (seven 28-day periods) while those in treatments IV, V, and VI were fed diet 1 for the first three 28-day periods and the diets indicated for the remaining four 28-day periods.

[2]Means not having the same superscript are significantly different ($P < 0.05$).

[3]The data presented for fertility represent that obtained in a test utilizing artificial insemination and conducted subsequent to the conclusion of the egg production trial.

[4]The treatment means presented represent the overall means for periods three to seven.

findings of Wheeler and Hoffman (1948b) and Godfrey (1949). Similarly McCartney and Shaffner (1950) reported that feeding thyroprotein at a level of 22g per 100 kg of feed to broiler hens had no effect upon subsequent fertility. It is of interest to note from the results of the present experiment that although feeding thyroprotein at a level of 22g per 100 kg of feed did indeed depress fertility, a more pronounced depression in fertility was not observed when thyroprotein was fed at twice this level.

It appears that the length of time that the hens have been on thyroprotein supplements is very important. The fertility of the eggs from the hens on diets 2 and 3 (treatments II and III respectively) were lower than those of the eggs from hens on similar diets in treatments IV and V respectively. It should be pointed out that these differences, while showing a trend, were not statistically significant. The hens in treatments II and III had been fed the thyroprotein diets from the start of the experiment, while those in treatments IV and V were fed thyroprotein from the beginning of the 4th experimental period. It appears from these results that either the age of hens at the time when thyroprotein is fed, or the length of time for which it is fed is associated with a decline in fertility.

Unfortunately, at the present time, very little is known about the influence of thyroprotein on the fertility

of eggs laid by thyroprotein-fed hens. It seems possible that the level of thyroprotein that may adversely affect one breed or strain of fowl may have a different effect on another breed or strain. Thus before a conclusion can be reached concerning the effects of thyroprotein on fertility of eggs produced by thyroprotein-fed hens, more work has to be carried out in this area.

The respective levels of fertility of eggs laid by four similar groups of White Leghorn hens, fed a standard layer diet, inseminated with semen from broiler-type males receiving either 0, 11, 22, or 44g thyroprotein per 100 kg of feed, were 92, 97, 95 and 89%. The statistical analysis of these data indicate that the ability of the broiler-type males to produce viable semen was not significantly affected by thyroprotein feeding (Appendix Table 7). These results are in agreement with those reported by Huston and Wheeler (1949). Furthermore, these findings appear to be at variance with the report of Shaffner (1948) who found that feeding thyroprotein (22g per 100 kg of feed) to broiler-type males significantly reduced the fertilizing capacity of the sperm as evaluated by artificial insemination. However, what Shaffner failed to take into account was that his roosters were two years old and as a result of age *per se* thyroprotein feeding might have had a detrimental effect on spermatogenesis.

Hatchability results (Appendix Table 8) indicate that thyroprotein feeding was markedly harmful. However, when a period analysis of hatchability was carried out, the data showed that hatchability values for treatments II and III were significantly ($P<0.01$) reduced below that of the control only in period 1. In this period, hatchability of the eggs from the hens in treatment I (control) was 80% while that for treatments I and II was 29 and 15% respectively. However, as seen in Table VII, there were no significant differences in hatchability between any of the six treatments from periods 3 through 7. These results, showing little or no effect of thyroprotein on hatchability, confirm those of Godfrey (1949), Huston and Wheeler (1949), McCartney and Shaffner (1950), and Savage et al. (1952).

The reduced hatchability observed for treatments II and III in period 1 tend to indicate that thyroprotein feeding to hens at 26 weeks of age was detrimental; however, after an adjustment period the birds adapted physiologically to the thyroprotein. From the data in Table VII, it can be seen that hatchability of the eggs from treatments IV, V, and VI was not influenced by thyroprotein feeding. Thus it seems that older (38 vs 26 weeks of age) birds do not require an adjustment period.

It has been reported that the chicks hatched from eggs laid by thyroprotein-fed hens took a longer period of

time to hatch than did the controls (Wheeler and Hoffmann, 1948b). In addition McCartney and Shaffner (1949) observed that eggs from thyroprotein-fed hens required an additional 12.3 hours incubation. This phenomenon was witnessed in the present investigation, but no detailed study of the delayed hatch was made. However, in an attempt to reduce losses due to a delayed hatching time, the eggs were incubated for an additional 24 hours.

McCartney and Shaffner (1949) reported that chicks produced by females fed thyroprotein exhibit a functional hypothyroid condition. These authors suggested that the production of chicks with goiterous thyroid glands might have been caused by a small amount of thyroprotein being transmitted from the treated hens to the eggs and this thyroprotein acted to cause the hypertrophy. If the goiterous chicks were placed on a standard starter diet at the time of hatch, their thyroids became reduced within the normal range in about 15 days (Wheeler and Hoffmann, 1948b).

However, it is not known to what extent the viability of the goiterous chicks is affected during the 15 days in which their glands are returning to within the normal size range. Thus the efficacy of thyroprotein as a dietary supplement for broiler breeding hens cannot be completely evaluated without further research to determine the viability of hypothyroid chicks from the day of hatch to

marketing weight.

SUMMARY AND CONCLUSION

An evaluation of the influence of dietary thyroprotein on egg production, feed consumption, feed efficiency, body weight gain, egg weight, egg shell thickness, mortality, fertility and hatchability of eggs, of Hubbard broiler breeding hens has been presented. Four levels of thyroprotein (0, 11, 22 and 44g per 100 kg of feed) were employed. The 11 and 22g levels were fed both throughout the laying cycle and during the latter part of the cycle while the 44g level was fed only during the latter part of the laying cycle. Under the conditions of these investigations the following results were observed:

1. Egg production was markedly improved in the hens fed thyroprotein at a level of 11g per 100 kg of feed. The higher levels of thyroprotein fed to hens in the latter part of their laying cycle seemed to increase the rate of decline in egg production.
2. Feed consumption and feed efficiency were not affected significantly by any of the levels of dietary thyroprotein. However, feed consumption decreased at the initiation of thyroprotein feeding, but the birds were able to adjust to the thyroprotein diet within a few weeks so that they

consumed a similar amount of feed as the controls over the entire experiment.

3. The feeding of thyroprotein was without effect on the mortality rate of the hens as there was no relation between level and mortality rate.

4. The 22g thyroprotein supplement, when fed during the latter part of the laying cycle caused a marked decrease in body weight gain as did the 44g supplement.

5. Egg weight was reduced whenever levels of thyroprotein greater than 11g per 100 kg of feed were fed to hens during the latter part of the laying cycle.

6. Thyroprotein feeding produced no measurable improvement in the thickness of egg shells.

7. The fertilizing capacity of semen from thyroprotein-fed males was not affected by any of the dietary levels of thyroprotein. However, the viability of the ova of the hens fed thyroprotein at both the 22 and 44g levels was greatly reduced. Furthermore, the effect of thyroprotein on fertility was more pronounced in those hens fed thyroprotein throughout the entire laying cycle.

8. Hatchability was not affected significantly by dietary thyroprotein except that on the initiation of

thyroprotein feeding a depression in hatchability occurred during the first 28-day period. This temporary depression in hatchability was observed only with hens that were fed thyroprotein from the beginning of the laying cycle.

The results of the present study indicate that thyroprotein supplemented diets increased egg production in broiler breeding hens. The optimum level of thyroprotein as a supplement was found to be 11g per 100 kg of feed. At this level egg production was significantly increased and fertility was not adversely affected. The viability of the ova of the hens fed the higher levels of thyroprotein was markedly reduced. In contrast, neither the quality nor the viability of semen produced by thyroprotein-fed males was reduced.

Hatchability of the eggs laid by the hens fed thyroprotein at the start of the laying cycle was drastically reduced. However, this reduction was only temporary because once the hens had become physiologically adjusted to their thyroprotein diets, hatchability returned to a level comparable with that of the control. Thus the benefit of feeding thyroprotein from the start of the laying cycle to increase egg production is negated by the reduced hatchability of the eggs. In addition, the eggs from treated hens require a longer than normal incubation time and when hatched the chicks are in a hypothyroid condition.

Furthermore, the viability of those hypothyroid chicks during their rearing to market weight and especially during their initial growing stage is unknown at the present time, indicating the need for further research. As in all new fields of investigation the solution of one problem invariably calls attention to several others that are awaiting solution.

BIBLIOGRAPHY

Ackerson, C. W., R. L. Borchers, J. E. Temper, and F. E. Mussehl, 1950. The utilization of food elements by growing chicks. XII. The effect of additions of iodocasein and vitamin concentrate to the ration. Poultry Sci. 29:640.

Andrews, F. N., and E. E. Schnetzler, 1946. Influence of thiouracil on growth and fattening in broilers. Poultry Sci. 25:124.

Asmundson, V. S., 1931. Effect of hormones on the formation of the hen's egg. Poultry Sci. 10:157.

Asmundson, V. S., and P. Pinsky, 1935. The effect of the thyroid on the formation of the hen's egg. Poultry Sci. 14:99.

Asmundson, V. S., H. J. Almquist, and A. A. Klose, 1936. Effect of different forms of iodine on laying hens. J. Nutr. 12:1.

Berg, L. R., and G. E. Bearse, 1951. Effect of iodinated casein and thiouracil on the performance of laying birds. Poultry Sci. 30:21.

Blaxter, K. L., E. P. Reineke, E. W. Crampton, and W. E. Peterson, 1949. The role of thyroidal materials and of synthetic goitrogens in animal production and appraisal of their practical use. J. Anim. Sci. 8:307.

Booker, E. E., and Pauld D. Sturkie, 1950. Relationship of rate of thyroxine secretion to rate of egg production in the domestic fowl. Poultry Sci. 29:240.

Burrows, W. H., and J. P. Quinn, 1935. A method of obtaining spermatozoa from the domestic fowl. Poultry Sci. 15:251.

Burrows, W. H., and J. P. Quinn, 1937. The collection of spermatozoa from the domestic fowl and turkey. Poultry Sci. 16:19.

Cole, L. J., and F. B. Hutt, 1927. Further experiments in feeding thyroid to fowls. Poultry Sci. 7:60.

Craft, W. A., C. H. McElroy, and R. Penquite, 1926. The influence of certain feeds upon the production of spermatozoa by the domestic chicken. Poultry Sci. 5:187.

Crew, F. A. E., 1925. Rejuvenation of the aged fowl through thyroid medication. Proc. Roy. Soc. Edin. 45:252.

Crew, F. A. E., and J. S. Huxley, 1923. The relation of internal secretion of reproduction and growth in the domestic fowl. Vet. Journ. 29:343.

Duncan, D. B., 1955. Multiple range and multiple F tests. Biometrics, 11:1.

Godfrey, G. F., 1949. The effect of feeding thyroprotein on egg shell quality and hatchability. Poultry Sci. 28:867.

Glazner, E. W., and C. S. Shaffner, 1948. Thyroid activity as related to strain differences in growing chickens. Poultry Sci. 27:664.

Gutteridge, H. S., and J. M. Pratt, 1946. The effect of vitamins D_2 and D_3 in fish oils and of iodocasein on shell quality. Poultry Sci. 25:89.

Gutteridge, H. S., and M. Novikoff, 1947. The effect of natural and synthetic vitamins D_2 and D_3 and of thyroprotein on egg shell quality. Poultry Sci. 26:210.

Hays, F. A., 1948. Thyroxine and artificial light as activators in the spermatogenesis of males. Poultry Sci. 27:84.

Hoffmann, E., and R. S. Wheeler, 1948. The value of thyroprotein in starting, growing and laying rations. IV. Effect on the egg production, shell quality, and body weight of year-old pullets during hot weather. Poultry Sci. 27:609.

Hoffmann, E., and C. S. Shaffner, 1950. Thyroid weight and function as influenced by environmental temperature. Poultry Sci. 29:365.

Hoshino, S., H. Doizaki, and K. Morimoto, 1968. Effects of iodocasein feeding on broiler thyroid. Poultry Sci. 47:1928.

Huston, T. M., and R. S. Wheeler, 1949. Effect of synthetic thyroprotein on seasonal variation in volume and concentration of cock semen. Poultry Sci. 28:262.

Huston, T. M., T. E. Cotton, and J. L. Carmon, 1962a. The influence of high environmental temperature on oxygen consumption of mature domestic fowl. Poultry Sci. 41:179.

Huston, T. M., H. M. Edwards, Jr., and J. J. Williams, 1962b. The effects of high environmental temperature on thyroid secretion rate of domestic fowl. Poultry Sci. 41:640.

Hutt, F. B., and R. S. Gowe, 1948. On the supposed effect of iodocasein upon egg production. Poultry Sci. 27:286.

Irwin, M. R., E. P. Reineke, and C. W. Turner, 1943. Effect of feeding thyroactive iodocasein on growth, feathering, and weights of glands of young chicks. Poultry Sci. 22:374.

Jull, M. A., and J. P. Quinn, 1931. The inheritance of body weight in the domestic fowl. Jour. Hered. 22:283.

Kumaran, J. D. S., and C. W. Turner, 1949. The endocrinology of spermatogenesis in birds. III. Effect of hypo- and hyperthyroidism. Poultry Sci. 28:653.

Lillie, R. J., J. R. Sizemore, J. L. Milligan, and H. R. Bird, 1952. Thyroprotein and fat in laying diets. Poultry Sci. 31:1037.

McCartney, M. G., and C. S. Shaffner, 1949. Chick thyroid size and incubation period as influenced by thyroxine, thiouracil, and thyroprotein. Poultry Sci. 28:223.

McCartney, M. G., and C. S. Shaffner, 1950. The influence of altered metabolism upon fertility and hatchability in the female fowl. Poultry Sci. 29:67.

Mellen, W. J., and F. W. Hill, 1954. Basal metabolism and thyroid size in chickens fed thiouracil and a thiouracil-thyroprotein combination. Poultry Sci. 33:872.

Miller, B. F., P. E. Sanford, and R. E. Clegg, 1962. The effect of thyroxine on egg production and egg quality of normal and radio-thyroid-ecrecticized hens. Poultry Sci. 41:989.

Moore, A. C., and H. G. Rees, 1948. The effect of iodized protein on the laying capacity of hens. British Vet. J. 104:156.

Moreng, R. E., and C. S. Shaffner, 1949. A thiouracil-thyroprotein treatment for fattening poultry. Poultry Sci. 28:504.

Mueller, W. J., and A. A. Amezcua, 1959. The relationship between certain thyroid characteristics of pullets and their egg production, body weight, and environment. Poultry Sci. 38:620.

Oloufa, M. M., 1953. Effect of thyroprotein on egg production, egg weight, and body weight of chickens during summer. Poultry Sci. 32:391.

Oloufa, M. M., 1955. Effect of thyroprotein on the growth of Egyptian baby chickens. Poultry Sci. 34:1292.

Quisenberry, J. H., and W. F. Krueger, 1948. Effects of feeding various combinations of protamone, oestrogens, and thiouracil on growth and fattening of broilers and fryers. Poultry Sci. 47:681.

Reineke, E. P., and C. W. Turner, 1942. Formation in vitro of highly active thyroproteins, their biological assay and practical use. Mo. Agr. Exp. Sta. Res. Bul. 315.

Savage, J. E., C. W. Turner, H. J. Kempster, and A. G. Hogan, 1952. The effects of vitamin B_{12} and thyroprotein on egg production, egg weight, shell quality and hatchability. Poultry Sci. 31:22.

Schultze, A. B., and C. W. Turner, 1945. The determination of the rate of thyroxine secretion by certain domestic animals. Mo. Agr. Exp. Sta. Res. Bul. 392.

Shaffner, C. S., 1948. The influence of thyroprotein-feeding on semen quality. Poultry Sci. 27:527.

Shaffner, C. S., and F. N. Andrews, 1948. The influence of thiouracil on semen quality in the fowl. Poultry Sci. 27:91.

Singh, H., and C. S. Shaffner, 1950. Effect of thyroprotein and caloric level of diet on metabolic rate of chickens. Poultry Sci. 29:575.

Snedecor, G. W., 1956. Statistical Methods, Fifth Edition. The Iowa State College Press, Ames, Iowa.

Taylor, L. W., and B. R. Burmester, 1940. Effect of thyroidectomy on production, quality, and composition of chicken eggs. Poultry Sci. 19:326.

Todd, A. C., 1948. Thyroactive iodocasein and thiouracil in the diet, and growth of parasitized chicks. Poultry Sci. 27:818.

Turner, C. W., 1948a. Effect of age and season on the thyroxine secretion rate of White Leghorn hens. Poultry Sci. 27:146.

Turner, C. W., 1948b. Effect of thyroprotein-feeding on the gland and organ weights of two-year-old White Leghorn hens. Poultry Sci. 27:155.

Turner, C. W., 1948c. Feeding thyroprotein and sex hormones to laying hens. Poultry Sci. 27:613.

Turner, C. W., M. R. Irwin, and E. P. Reineke, 1944. Effect of feeding thyroactive iodocasein to Barred Rock cockerels. Poultry Sci. 23:242.

Turner, C. W., M. R. Irwin, and E. P. Reineke, 1945a. Effect of the thyroid hormone on egg production of White Leghorn hens. Poultry Sci. 24:171.

Turner, C. W., and H. L. Kempster, 1947. Effect of hyperthyroidism on seasonal and yearly egg production of fowls with advancing age. Amer. Jour. Physiol. 149:383.

Turner, C. W., and H. L. Kempster, 1948. Mild hyperthyroidism maintains egg production with advancing age. Poultry Sci. 27:453.

Turner, C. W., and H. L. Kempster, 1949. Thyroprotein-feeding to 7- year-old hens. Poultry Sci. 28:826.

Turner, C. W., H. L. Kempster, and N. M. Hall, 1946. Effect of continued thyroprotein feeding on egg production. Poultry Sci. 25:562.

Turner, C. W., H. L. Kempster, N. M. Hall, and E. P. Reineke, 1945b. The effect of thyroprotein on egg production. Poultry Sci. 24:522.

Warren, D. C., and R. L. Schnepel, 1940. The effect of air temperatures on egg shell thickness in the fowl. Poultry Sci. 19:67.

Wheeler, N. C., and F. N. Andrews, 1943. The influence of season on semen production in the domestic fowl. Poultry Sci. 22:361.

Wheeler, R. S., and E. Hoffmann, 1948a. The value of thyroprotein in starting, growing and laying rations. II. The growing period 12-24 weeks of age. Poultry Sci. 27:509.

Wheeler, R. S., and E. Hoffmann, 1948b. The value of thyroprotein in starting, growing, and laying rations. III. Egg production, fertility, and hatchability in Rhode Island Red pullets. Poultry Sci. 27:685.

Wheeler, R. S., and E. Hoffmann, 1948. Goitrous chicks from thyroprotein-fed hens. Endocrinology, 42:326.

Wheeler, R. S., E. Hoffmann, and C. L. Graham, 1948. The value of thyroprotein in starting, growing and laying rations. I. Growth, feathering and feed consumption of Rhode Island Red broilers. Poultry Sci. 27:103.

Wilson, W. O., 1949. High environmental temperatures as affecting the reaction of laying hens to iodized casein. Poultry Sci. 28:581.

Winchester, C. F., 1939. Influence of thyroid on egg production. Endocrinology, 24:697.

Winchester, C. F., and G. K. Davis, 1952. Influence of thyroxine on growth of chickens. Poultry Sci. 31:31.

Winchester, C. F., and V. C. Scarborough, 1953. The influence of thyroxine on growth and egg production of chickens. Poultry Sci. 32:423.

Winchester, C. F., C. L. Comar, and G. K. Davis, 1949. Thyroid destruction by I^{131}, and replacement therapy. Science, 110:302.

APPENDIX

APPENDIX TABLE 1. Average hen-day egg production (%) of each of four replicates per treatment illustrated for each 28-day period throughout the experiment

Treatment		Period						
		1	2	3	4	5	6	7
I	Replicate 1	41.6	72.5	63.4	57.1	57.8	57.3	59.8
	Replicate 2	47.2	74.7	75.6	68.2	65.4	64.4	58.3
	Replicate 3	46.9	71.6	63.6	62.3	52.6	54.4	52.7
	Replicate 4	35.1	75.7	66.8	61.9	56.0	51.1	53.4
II	Replicate 1	38.8	69.3	72.4	72.1	67.2	60.5	63.7
	Replicate 2	47.7	71.4	73.6	64.4	59.2	52.2	55.9
	Replicate 3	40.7	72.5	77.1	73.5	62.4	62.8	68.8
	Replicate 4	38.5	73.9	75.2	66.9	58.2	61.1	64.7
III	Replicate 1	49.7	59.5	71.7	67.3	65.0	56.6	55.1
	Replicate 2	31.8	57.3	68.7	62.0	61.6	57.5	61.2
	Replicate 3	43.0	61.9	78.7	71.8	64.1	62.4	69.6
	Replicate 4	43.7	71.6	75.3	68.9	65.5	58.0	62.7
IV	Replicate 1	44.1	78.7	74.9	73.3	65.8	65.5	58.3
	Replicate 2	46.6	73.6	68.2	67.2	62.2	64.1	58.3
	Replicate 3	56.6	78.0	75.7	77.5	65.4	61.3	55.7
	Replicate 4	41.2	76.8	73.2	63.4	61.7	58.2	53.6
V*	Replicate 1	49.9	78.7	73.9	70.4	61.6	65.5	63.6
	Replicate 2	53.9	73.8	73.9	71.0	56.0	45.0	48.9
	Replicate 3	25.8	43.2	53.1	67.2	60.0	47.2	40.6
	Replicate 4	37.4	69.2	67.4	66.4	64.2	55.2	57.8
VI	Replicate 1	53.6	79.4	75.5	69.5	52.8	49.9	50.0
	Replicate 2	48.4	73.9	73.1	59.9	56.3	47.9	45.0
	Replicate 3	41.6	80.6	77.3	68.0	63.6	61.0	54.2
	Replicate 4	43.6	63.9	75.1	66.4	51.1	47.0	43.0

*Replicate 3 in treatment V was not included in the statistical analysis of egg production or of feed efficiency because of its unexplainable low egg production.

APPENDIX TABLE 2. Analysis of variance of egg production, feed consumption, feed efficiency, and mortality data obtained with broiler breeding hens fed various thyroprotein-supplemented diets

Source of Variance	Degrees of Freedom[1]				Mean Squares[1,2]			
	EP.	FC.	FE.	M.	EP.	FC.	FE.	M.
Treatments	5	5	5	5	23.3*	0.001	1521.1	44.89
Periods	6	-	6	-	840.8*	-	52851.2*	-
T x P	30	-	30	-	19.0	-	1160.9	-
Error	11.9	18	119	18	9.5	0.002	847.9	71.14

[1](EP) egg production; (FC) feed consumption; (FE) feed efficiency; (M) mortality.

[2]Significantly different (*) at $P < 0.05$.

APPENDIX TABLE 3. Average feed consumption per hen per day (g) of each treatment illustrated for each 28-day period throughout the experiment

Treatment[1]	Period 1	2	3	4	5	6	7
I	167.1	178.9	174.1	180.8	180.2	176.2	185.7
II	156.6	170.2	181.0	188.1	183.9	188.1	189.3
III	149.8	163.4	186.6	183.0	184.3	188.4	193.0
IV	167.5	184.8	178.9	171.0	180.6	188.9	181.9
V	164.8	179.8	178.0	170.7	178.0	176.2	183.0
VI	163.4	180.2	177.1	152.5	168.4	175.7	183.0

[1]Replicate 3 in treatment V was not included in the statistical analysis of egg production or of feed efficiency because of its unexplainable low egg production.

APPENDIX TABLE 4. Analysis of variance of body weight gain data obtained with broiler breeding hens fed various thyroprotein-supplemented diets

Source of Variance	Degrees of Freedom[1]			Mean Squares[2,3]		
	A	B	C	A	B	C
Treatments	5	5	5	0.49**	0.17*	0.60*
Error	18	18	18	0.10	0.09	0.04

[1]A, B, and C represent analyses of data for periods 1 through 7; periods 1 through 3; and periods 4 through 7, respectively.

[2]Significantly different (**) at $P < 0.01$.

[3]Significantly different (*) at $P < 0.05$.

APPENDIX TABLE 5. Analysis of variance of egg weight and egg shell thickness data obtained with broiler breeding hens fed various thyroprotein-supplemented diets

Source of Variance	Degrees of Freedom		Mean Squares[1]	
	Egg weight	Egg shell thickness	Egg weight	Egg shell thickness
Treatments	5	5	6.50*	0.17
Periods	4	1	16.42	0.65
T x P	20	5	0.90	0.39
Error	90	36	1.20	0.55

[1]Significantly different (*) at $P < 0.05$.

APPENDIX TABLE 6. Analysis of variance of fertility data obtained with eggs of broiler breeding hens fed various thyroprotein-supplemented diets

Source of Variance	Degrees of Freedom	Mean Squares
Treatments	5	511.7
Periods	5	112.4
T x P	25	117.2
Error	108	235.0

APPENDIX TABLE 7. Analysis of variance of fertility data obtained with eggs of Hubbard breeding hens fed various thyroprotein-supplemented diets, and White Leghorn hens fed a standard layer diet

Source of Variance	Degrees of Freedom[1] H.	W.L.	Mean Squares[1,2] H.	W.L.
Treatments	5	3	54.9*	41.8
Error	6	4	7.6	47.8

[1](H.) Hubbard hens; (W.L.) White Leghorn hens.

[2]Significantly different (*) at $P < 0.05$.

APPENDIX TABLE 8. Analysis of variance of hatchability data obtained with eggs of broiler breeding hens fed various thyroprotein-supplemented diets

Source of Variance	Degrees of Freedom[1]			Mean Squares[1,2]		
	A	B	C	A	B	C
Treatments	5	2	5	405.5**	812.0**	204.3
Periods	5	-	4	634.7**	-	227.5
T x P	25	-	20	523.9**	-	163.4
Error	108	9	90	97.9	56.9	105.4

[1]A, B, and C represent analysis of data for periods 1 through 7 (data was not collected for period 2); period 1; and period 3 through 7, respectively.

[2]Significantly different (**) at $P < 0.01$.