THE EFFECT OF CAPONIZATION AND ESTRADIOL-17β-MONOPALMITATE ON PRODUCTION, CHEMICAL COMPOSITION AND ORGANOLEPTIC QUALITY OF BROILERS

by

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The past five years per capita consumption of poultry has increased at a greater rate than the total per capita consumption of red meat. For poultry meat to remain in demand and for the consumer to find it even more desirable, the poultry industry must produce a superior product.

Appearance, juiciness, tenderness and flavor are important characteristics of quality. A clean, wholesome-looking product is the first step in attracting the attention of the consumer. Thereafter, the pleasure of eating the chicken must be of such intensity that the consumer continues to purchase increasing amounts.

The amount of fat in meat influences its quality. For example, an increase in subcutaneous fat improves the appearance of the dressed carcass while an increase in muscle fat influences juiciness and tenderness. Flavor is less affected by fat than are other quality factors.

For centuries capons have been known for increased fat deposition and for their flesh to remain juicy and tender long after cocks have become staggy and their flesh rather coarse, stringy and tough. Likewise, estrogen treatments stimulate fattening and have been administered to chickens as a substitute for caponization.

Since the greatest percentage of poultry meat consumed is from broilers, the use of estrogenic compounds could play an important role in broiler production. The use of estrogenic substances as "food additives" requires the approval of the Food and Drug Administration and most estrogenic substances are not so approved. Estradiol-17β-monopalmitate, however, has been approved for use in fattening and improving the finish of chickens.

The objectives of this study were to compare the effects of caponization and estradiol-17β-monopalmitate injection on the following.

1. Growth rate and feed efficiency.
2. Dressing percentage, eviscerated weight and subcutaneous fattening.
3. Percentage moisture and percentage fat in the light meat, dark meat and liver.
4. Thawing loss, cooking loss, and cooking time.
5. Juciness, tenderness, flavor and overall preference of the cooked meat as scored by a taste panel.

REVIEW OF LITERATURE

For many years estrogenic compounds have been known to have metabolic effects on chickens. The main effect being increased fat deposition throughout the body. The use of such a compound in broiler production could be important if it were convenient, effective, and economical to use. Dodds and Lawson (1937) and Dodds et al. (1938, 1939) synthesized diethylstilbestrol and Deansley and Parkes (1937) and Mark and Biskind (1940) developed the implantation method of administration. Diethylstilbestrol was then used successfully by many for a number of years. However, in 1959 the Food and Drug Administration banned the use of diethylstilbestrol in poultry production for human consumption because residue of the hormone was found to be present in the tissue of the dressed carcass of birds so treated.

In 1964 the Food and Drug Administration approved the use of an estrogenic compound that produces the fattening effect for which diethylstilbestrol was known. This compound is estradiol-17β-monopalmitate.

Little has been reported in the literature concerning the use of estradiol-17β-monopalmitate in broiler production. Therefore, the author wishes to review literature concerning both estradiol-17β-monopalmitate and certain other estrogenic compounds, primarily diethylstilbestrol, to establish a background knowledge of the use of estrogenic compounds in chickens.

The Effect of Diethylstilbestrol on Weight Gain

An increase in feed consumption during estrogen treatment has been consistently observed by Thayer et al. (1944), Andrews and Bohren (1947),

Detwiler et al. (1950), Baum et al. (1951), Stadelman et al. (1951), Begin and Grainger (1957), Lauffer (1957), Carew and Hill (1959), and Boone (1961).

Increased weight gains in birds treated with diethylstilbestrol have been reported by Sturkie (1946a), Andrews and Bohren (1947), and Baum et al. (1951).

Lorenz (1945b) noted older birds exhibited more weight gain response to diethylstilbestrol treatment than younger birds. Treated birds killed prior to 10 weeks of age weighed about the same as controls. Between 10 and 18 weeks of age the treated birds weighed about 50 to 100 g more than controls. At 5 months of age the hormone treated birds gained 200 to 300 g more than controls. Increased gains were of the same magnitude as the amount of additional fat deposited by the hormonized birds.

When 6-week old chickens were administered a 12 mg diethylstilbestrol pellet, Stadelman et al. (1951) observed a highly significant increase in gain during the first 2 weeks after implantation. The extra weight was maintained but not increased throughout the remainder of the 12-week treatment period. Donovan and Sherman (1960) also observed weight gain was accelerated during the first 14 days following implantation with maximum acceleration obtained by the seventh day following implanting.

Stadelman et al. (1956) reported chickens injected with diethylstilbestrol differed only slightly in live weight and eviscerated weight at 6 weeks of age. At 10 weeks of age a highly significant increase was noted in live and eviscerated weights.

Issawi et al. (1956) reported increased gain in body weight varied with breed and age at diethylstilbestrol implantation. Moreng and Bryant

(1956) observed diethylstilbestrol pellet implants effectively increased body weight gain during a 4-week treatment period but there was no marked difference in breed response to the treatment.

Lauffer (1957) administered 15 mg of diethylstilbestrol subcutaneously to 8-week old chickens and noted at 13 weeks of age they showed no significant increase in body weight compared to controls and birds caponized at 4 weeks of age. At 24 weeks of age the diethylstilbestrol treated birds were significantly heavier than capons and controls. Begin and Grainer (1957) reported caponization had an adverse effect on growth for the first half of the trial but this was overcome by the time the birds were 17 weeks of age so there was no marked effect on growth rate compared to diethylstilbestrol implanted birds. They also observed diethylstilbestrol pellets were slightly superior to diethylstilbestrol paste for improving weight gains. Sturkie (1946b) observed no significant difference between estrogen treated males, capons and controls for average weight gain or between pelleted old cocks and controls. Diethylstilbestrol treated birds were heavier than the capons and the capons heavier than the control birds.

Gassner and Wilgus (1948) and Helbert and Brunson (1957) found growth of broilers and roasters was not markedly affected by diethylstilbestrol treatments. Likewise, Sturkie (1946a) observed no significant increase in body weight of 18 to 20 month old White Leghorn cocks treated with diethylstilbestrol for 29 days. Carcass quality of the hormonized birds was increased.

Lorenz (1943) implanted birds with diethylstilbestrol at 3 weeks of age and recorded the effects between 7 and 11 weeks of age. He found the hormonized birds to be heavier at 8 weeks of age but by 11 weeks of age

the difference was lost and in fact the treated birds weighed less than controls.

Boone et al. (1961) reported the use of diethylstilbestrol in broilers did not prove to be beneficial except for increasing abdominal fat. Total weight gains were less for treated birds than for controls.

The Effect of Diethylstilbestrol on Feed Efficiency

There is no consistent trend in feed efficiency of diethylstilbestrol treated birds. The age at which the birds are hormonized, the length of the trial and the dosage administered apparently do not influence feed efficiency to any great degree. Andrews and Bohren (1947), Baum et al. (1951) and Detwiler et al. (1950) found there was no difference in feed efficiency of diethylstilbestrol treated birds and controls. Hebert and Brunson (1957) noted feed efficiency was significantly reduced by a subcutaneous implantation of diethylstilbestrol in 5-week old cockerels. Similarly, Gassner and Wilgus (1948), Begin and Grainger (1957) and Boone et al. (1961) reported an adverse effect on feed conversion of treated birds. The decrease in feed efficiency was usually very small. Improved feed efficiency has been reported. Lauffer (1957) reported hormonized chickens tend to use feed more efficiently than capons or controls although the differences among the 3 groups were small.

The Effect of Oral Administration of Diethylstilbestrol

Diethylstilbestrol has a relatively low oral potency for chickens and rather large doses are required to produce fattening as reported by Jaap and Thayer (1944), Thayer et al. (1944), Jaap (1945) and Munro and Kosin (1946).

Lorenz (1945a) fed diethylstilbestrol to cockerels at various doses

up to 240 mg per bird over a 4-week period and observed only little, if any, increase in weight gain. Small extra gains were of the same magnitude as the amount of extra fat deposited. Thayer et al. (1944, 1945) found the oral estrogenic potency of diethylstilbestrol to be insufficient for practical use in fattening. They fed 23 mg per pound of feed to 8-week old fryers for 4 weeks and 200 mg per pound of feed for 5 weeks to old cocks in the first experiment. In the second experiment, chickens ranging in age from 8 weeks to old cocks were given doses up to 50 g daily for 2 to 4 weeks prior to marketing.

In some trials oral administration of diethylstilbestrol has been effective in improving the finish of broilers. Glazener and Jull (1946) obtained excellent fattening of 6-week old cockerels by feeding 30 mg per bird per day for 3 weeks. Sykes et al. (1945) fed diethylstilbestrol at the level of 1 mg per day and noted some improvement in the market grade of the treated birds. The age of the bird when feeding started had no noticeable effect on the effectiveness of the diethylstilbestrol treatment. Also, there was apparently no noticeable advantage in feeding diethylstilbestrol beyond 6 weeks.

The Effect of Feeding Dianisylhexene

Estrogenic compounds other than diethylstilbestrol have been used to improve the finish of broilers. Dienestrol diacetate and dianisylhexene have proven to be the most useful of these. Dianisylhexene is a dimethyl ether of diethylstilbestrol.

Thayer et al. (1944, 1945) found 50 mg of dianisylhexene per pound of feed produced fattening in both 6-week old and 20-week old birds. When higher levels than this, such as 100 mg per pound of feed, were fed,

lipemia and often death resulted. Feeding the level of 40-50 mg per pound of feed for 3 to 4 weeks was suggested to be the optimum dosage and time. Similarly, Lorenz (1945a) observed a moderate increase in fattening even though total weight gains were not increased.

Glazener and Jull (1946) fed dianisylhexene for two weeks at 50 mg per pound of feed but observed no improvement in weight gain or finish and no increase in feed consumption.

Thayer and Gross (1946) reported feeding dianisylhexene did not increase weight gain although market grade of broilers was slightly improved. No increase in fattening was observed in hens. Although weight gains may or may not be altered, the general observation is that fattening of the birds increases when dianisylhexene is fed at a near optimum level.

The Effect of Feeding Dienestrol Diacetate

Dienestrol diacetate when fed to chickens has been shown to promote fattening. Begin and Grainger (1947) fed 95.34 mg of dienestrol diacetate per pound of feed to 7-month old cockerels for 6 weeks and noted an increase in fat deposition. They also fed dienestrol diacetate at the level of 31.8 and 95.34 mg per pound of feed to growing chickens and even though growth rate was not affected, carcass quality was improved. The estrogenic treatments had an adverse effect on feed conversion in all trials. Lorenz and Bachman (1947) observed that weight gains were increased slightly in 8 to 12 week old cockerels fed dienestrol diacetate. Quisenberry and Krueger (1948) reported that feed efficiency was depressed by feeding dienestrol diacetate but no other effects were observed.

Interaction Between Diet and Estrogens

It is only natural that to achieve maximum growth and fattening of

broilers the diet fed must provide the optimum nutritional balance. Thayer (1946), Adams (1955), Carew and Hill (1959) and others have studied the interaction between diet and response to estrogenic treatments.

Bird (1948) fed diets containing 15 percent and 18 percent protein to 12-week old cockerels treated with diethylstilbestrol. Birds fed the high protein diet gained more weight and had better feed efficiency than those fed the low protein diet. Similarly, Camp et al. (1957) compared growth response obtained from an estrogen injection when protein levels of 14, 16, 18 and 21 percent were fed. They found hormonized birds increased in growth rate on the 14, 16 and 18 percent protein diets. No growth response was observed in birds fed the 21 percent protein diet.

Essary et al. (1965) fed birds from 1-day old to 12 weeks of age, lowering the protein level at 6 weeks of age and increasing the calories of productive energy per pound. The levels were 22 and 18 percent protein with about 1,000 Calories per pound and 20 and 16 percent protein with about 875 Calories per pound. Live weight, feed efficiency and dressing percentage were improved by the higher level of protein and calories. Also, Essary et al. (1965) found different levels of added fat and protein fed to broilers from 1 day to 10 weeks of age significantly increased live weight but improved dressing percent only moderately. The amount of fat deposition appeared to be responsible for the difference in dressing percent.

Gassner and Wilgus (1948) noted a low fiber (high density) broiler mash gave superior gains and feed efficiency and improved carcass grade compared to the standard ration of that time.

Mattox and Moore (1964) recommend feeding a 20 percent protein grower

ration to broilers when injected with estradiol-17β-monopalmitate at five weeks of age. Beginning at 7 weeks of age add 10 percent cracked corn to the grower ration each week until birds are being fed 60 percent added corn at 14 weeks of age. This is equivalent to reducing the protein level from 18 percent at 5 weeks of age to 14 percent at 9 weeks of age with a high amount of carbohydrates in the diet.

The Effect of Estrogens on Dressing Percentage

It is generally observed that birds with a greater amount of finish have a higher dressing percentage than those with a lesser amount of finish. The difference being chiefly a result of the extra amount of fat on the dressed carcass and a proportionately less eviscerated loss.

Detwiler at al. (1950) noted diethylstilbestrol implants significantly increased the dressing percentage of broilers. Likewise, Lauffer (1957) reported the dressing percentage was significantly improved by hormone treatments of dienestrol diacetate and diethylstilbestrol compared to controls and capons.

Moreng and Bryant (1956) observed increased fat deposition in treated birds did not increase the processing loss. Stadleman et al. (1951) reported a greater weight loss in treated birds that were cut up for packaging. Sykes et al. (1945), Gassner and Wilgus (1948) and Sturkie (1946b) observed a significantly less amount of abdominal fat on controls than on capons and birds hormonized with either dienestrol diacetate or diethylstilbestrol.

Increasing the duration of the 20 mg diethylstilbestrol implant treatment in broilers was shown to increase the fattening effect of the treatment, Lorenz (1945b). Lorenz and Bachman (1947) observed that

lengthening the treatment period from 2 to 6 weeks without changing the total dose administered improved fattening using both dianisylhexene and dienestrol diacetate.

The Effect of Estrogens on Chemical Composition of Edible Tissue

Chemical analysis of tissue from hormonized chickens demonstrates the treatment has an effect on the chemical composition of the tissue. Generally as the fat percentage increases the moisture percentage and protein percentage decrease. Also, ash percentage may decrease because the increased amount of fat results in a relatively less amount of bone.

Lorenz (1945b) reported breast and leg fat was increased 130 percent to 150 percent by treatment with a diethylstilbestrol pellet.

Andrews and Bohren (1947) reported diethylstilbestrol significantly increased fat content and significantly decreased moisture content of the edible carcass. Similarly, Detwiler et al. (1950) and Hebert and Brunson (1957) noted an increase in fat and decrease in moisture and protein percentage of treated birds.

Lorenz (1943) found diethylstilbestrol implants greatly increased the fat content of broilers compared to controls. Breast muscle was 0.95 and 0.38 percent, leg tissue 9.2 and 3.3 percent, and liver 10.3 and 3.2 percent for caponettes and controls, respectively. Muscle tissue showed little progressive change in fat content during the 5 successive weeks of sampling which began 4 weeks after treatment. This indicated the increased fat deposition occurred within 4 weeks of treatment.

This was probably because of the loss of visceral fat. Camp et al. (1957) found dressing percentage rather variable but tended to be improved by hormone injection on low-protein diets.

The Effect of Estrogens on Carcass Finish, Carcass Quality and Market Grade

Carcass finish is generally improved by estrogen treatments. Thayer et al. (1945) reported the smooth, glossy texture of carcasses of estrogen treated birds was caused by the increased amount of subcutaneous fat and by the effect of estrogen on skin structure and feather growth. Also, the skin and fat of diethylstilbestrol fed birds was bleached to a pale, yellow tone, regardless of the age of the bird. Lauffer (1957) found a 15 mg diethylstilbestrol implant 8 weeks prior to slaughter or 31.75 mg dienestrol diacetate per pound of feed fed 3 weeks preceeding slaughter produced a bird superior in finish, fleshing and feathering at both 13 and 24 weeks of age compared to controls and capons. Similarly, Camp et al. (1957) reported finish, fleshing and pigment scores were higher for diethylstilbestrol treated broilers than for controls.

Sykes et al. (1945), Sturkie (1946a, 1946b), Andrews and Bohren (1947), Gassner and Wilgus (1948) and Boone et al. (1961) found hormone treated birds have a higher average market grade than control birds. Sturkie (1946b) reported that the carcass grade of treated birds was superior to that of controls and equal to or better than the carcass grade of capons.

Additional fat deposition induced by estrogen treatment is noted in all parts of the bird's body. The abdominal region perhaps undergoes the most noticeable increase in fat followed by subcutaneous deposits over the breast, back and leg regions. Lorenz (1943, 1944, 1945a, 1945b), Thayer et al. (1945), Lorenz and Bachman (1947), Moreng and Bryant (1956) and Begin and Grainger (1957) have all observed an increase in visceral fat. Muscle fat is increased also, especially in leg tissue, as reported by Lorenz (1943, 1945b).

The Effect of Estrogens on Juiciness, Tenderness and Flavor

Since metabolic and physiological changes are induced by estrogen treatment, it would seem reasonable to expect a possible effect on the palatability of the meat.

Glazener and Jull (1946) fed 30 mg of diethylstilbestrol per day for 3 weeks to 1 group of birds and to another group fed 50 mg of dianisylhexene per pound of feed for 2 weeks. They found the birds, particularly the females, were more highly flavored than controls. Much individual variation in preference was evident, however no one objected to the treated birds' flavor.

Fry et al. (1958) found chicken broth from 10 and 14 week old hormonized birds had a significantly less desirable flavor than broth from control birds. The flavor of baked chicken was not affected by the hormone treatment.

Sturkie (1946a, 1946b) reported only a slight improvement in flavor of 8-month old treated birds compared to controls and capons. Eighteen to 20-month old birds' eating qualities were not appreciably improved.

Wesley et al. (1958) injected chickens with 15 mg of diethylstilbestrol 3 weeks before dressing them. He found hormonization had no significant effect on juiciness of 6 and 10-week old birds but juiciness of birds dressed at 14 weeks of age was significantly increased by the hormone treatment. The estrogen treatment significantly increased tenderness in all except the 6 week old birds.

Lorenz (1945b) reported increased muscle fat of hormonized birds heightens the flavor and infiltrates the muscle connective tissue and makes the product more tender.

Pappin et al. (1954) reported chicken fat itself was only a minor source of flavor in poultry and that muscle tissue was a major source.

Effect of Estradiol-17β-monopalmitate on Poultry

Wesley et al. (1965) injected 6-week old chickens with a 10 mg dose of estradiol-17β-monopalmitate and noted a highly significant difference among strains with respect to response to the estrogen treatment. With the exception of only one strain, feed efficiency was improved by the hormone treatment.

Moreng and Hopwood (1965) hormonized 16-week old turkeys with estradiol-17β-monopalmitate using doses up to 60 mg per turkey. They reported hormonization significantly increased the weight gains in turkeys treated at 30 and 40 mg levels.

Birds injected with 30, 40, 50 and 60 mg doses of estradiol-17β-monopalmitate had lower dressing losses and higher finish scores than did control birds. A 20 mg dose of the estrogenic compound had no apparent effect on the turkeys.

EXPERIMENTAL PROCEDURE

Management

Commercial Cobb strain, male chickens were used to compare surgical caponization with an injection of estradiol-17β-monopalmitate. Production efficiencies, yields, chemical composition and organoleptic quality of roasters and broilers were compared.

Day-old chicks were vaccinated against Newcastle and Infectious Bronchitis prior to being housed in a 10' x 18' brooder pen at the Thomas B. Avery Poultry Research Center.

Feed and water were fed ad libitum. Kansas State University 21 Percent Protein Chick Starter Ration, (Appendix, Table 1), was fed to the birds until they were 5 weeks of age. Kansas State University 17 Percent Protein Chick Grower Ration, (Appendix, Table 2), was fed from 5 weeks of age until the experiments were terminated. All feed was mixed at the Kansas State University Flour and Feed Milling Industries facilities on campus. To start the birds, water was supplied in chick size glass waterers and feed was placed on egg flats. Otherwise, automatic waterers and hand-filled feed troughs were used.

All birds were debeaked at 2 weeks of age using an electric debeaker. Two-thirds of the upper beak was cut off and the lower beak was severed at the point where the fleshy tissue ends.

When the chickens reached the age at which treatment was to begin, they were weighed, wingbanded and randomly assigned to pens identical to those in which they had been reared. Equal numbers of chickens were placed in each pen. The birds to be caponized were deprived of feed for 24 hours,

then surgically caponized. Control and hormonized birds had feed and water at all times.

Mortality, feed consumption per pen and individual body weights were recorded weekly.

Experiment I

In a pilot project, 40 birds were randomly separated into two groups at 47 days of age. The birds in one group were surgically caponized, and those in the other group were each administered a 10 mg injection of estradiol-17β-monopalmitate.

Difficulty was experienced in caponizing at this age because the gonads were well developed. If the testicular wall was ruptured and even a particle of the gonad remained in the body, it regenerated and caused the bird to develop into a "slip."

In the pilot experiment, 8 of the 20 caponized birds developed into slips.

All birds were dressed at 89 days of age or 6 weeks after being either caponized or hormonized.

The pilot experiment was terminated after collecting growth and dressing percentage data.

Experiment II

Three hundred chickens were started for this experiment. They were divided into 3 groups--capons, caponettes and controls. Because of the difficulty encountered with caponization in the pilot project, the capons in this experiment were caponized at 26 days of age. Those in the caponette group were each injected with 10 mg of estradiol-17β-monopalmitate at 35 days of age--the minimum age recommended for treatment with this

estrogenic compound. The third group of chickens remained untreated and served as controls.

All birds were processed at 11 weeks of age and analyzed for chemical composition and organoleptic quality.

Treatment Procedure

The caponization operation was performed using a single incision. The wings and legs of the bird were fastened to a stand that allowed the bird to rest at a 45-degree angle from the floor. The legs were pulled to the rear of the bird and the wings were pulled upward. A few feathers were plucked just in front of the thigh where the incision was to be made. The skin over the ribs was pulled anterior as far as possible and an incision about 1 inch long was made between the last 2 ribs. The spreader was used to hold the ribs apart while the operation was completed. When necessary, the posterior air sac and peritoneum were torn away with a probe so the testes could be located. The lower testicle was removed by grasping it with an extractor then slowly pulling outward while making a twisting motion until the organ was severed from the body. The upper gonad was then removed in the same manner.

Following caponization, many of the birds developed wind puffs in the area of the operation. Most of these occurred the first week after the operation, but some continued to appear for 2 to 3 weeks following caponization. Each week, prior to weighing the birds, wind puffs were relieved by pricking the skin at the base of the bloated area with a knife and forcing the air out.

Hormonized birds were injected subcutaneously at the base of the skull with 10 mg of estradiol-17β-monopalmitate. A gun and needle designed for

this purpose were used. A cartridge which contains enough hormone to treat 51 birds was placed into the gun which was then cocked. A cap containing the needle was screwed onto the end of the gun. One person held the birds while another person injected the hormone into each bird. The gun was so designed that one trigger pull would administer the required 10 mg dose.

To eliminate the possibility of hormone residue, birds injected with estradiol-17β-monopalmitate are not to be slaughtered for consumption within 6 weeks of treatment. By the end of the 6 weeks period the hormone is completely metabolized by the bird's body. Therefore, the growth studies were terminated exactly 6 weeks after treatment with estradiol-17β-monopalmitate. Capons and controls were processed at this time also.

Processing

The birds were placed in crates and deprived of feed and water for 18 hours prior to weighing and processing. They were slaughtered and then eviscerated by cutting down each side of the backbone and removing the entire vertebral column. Carcasses were held in slush ice overnight, then weighed. Those randomly selected to be used for chemical analysis and organoleptic evaluation were cut into halves. The right halves were sealed in plastic bags, frozen and held at 0^{o} F until used for organoleptic evaluation. The corresponding left halves were analyzed to determine chemical composition.

Dressed weight included the carcass, vertebral column, heart, liver and gizzard.

Livers were handled and analyzed chemically by the same procedures used for the left carcass halves.

Chemical Composition

Moisture and fat determination were run on the whole liver, pectoralis major muscle for light meat and composite thigh muscle for dark meat. Each tissue sample was run through a Hobart meat tenderizer 4 times, placed on aluminum foil, weighed, dried 24 hours at 212° F in an air oven and weighed. The dried samples were ground in a hand meat grinder and stored in a small glass jar until analyzed for ether extractable content.

Ether extraction was performed using the procedure described in A.O.A.C., 1965, section 22.033. The fat was extracted with anhydrous ether in a soxhlet extractor for 4½ hours at 4 to 5 drops per second. Percent ether extract was calculated on fresh tissue or wet basis in all instances.

Organoleptic Evaluation

One-half chicken from each group was thawed overnight at room temperature. A meat thermometer was inserted into the center of the thickest portion of the breast. The halves of each bird were placed cut-side down on a wire rack over a pan and cooked at 325° F in an electrically heated rotary oven. As each chicken reached an internal breast temperature of 185° F it was removed from the rotary oven. Appropriate weights were recorded throughout the procedure to determine thawing loss, total cooking loss and cooking time of each carcass half. Immediately after cooking, Pectoralis major muscle (light meat) and composite thigh muscles (dark meat) were cut into one-half inch cubes, placed in warm, insulated containers and served to the taste panel. Each panel member received one cube of light meat and one cube of dark from each of the cooked broiler halves. Meat samples were scored for juiciness, tenderness and flavor using a scale of 1 to 7 (Appendix, Table 3). The samples were ranked for overall preference using a scale of 1 to 3, (Appendix, Table 3).

RESULTS AND DISCUSSION

The effect of caponization and estradiol-17β-monopalmitate on rate of gain, feed efficiency and dressing percentage is presented in Table 1. The first week of the experiment was the week immediately following the caponization of 1 group of birds. The capons gained only 128 g per bird during this period while the other 2 groups gained approximately 200 g per bird. The reduced rate of gain by the capons was only temporary and can be accounted for as a result of the stress caused by the caponization operation. The reduced rate of gain by the capons compared to controls was only about one-third as great during the second week following caponization. The caponettes were hormonized with a 10 mg dose of estradiol-17β-monopalmitate at the beginning of the second week of the experiment. This same week the caponettes demonstrated an apparent response by increasing in body weight at a faster rate than both capons and controls.

During the third week of the experiment the capons had recovered and, in fact, gained more weight than the controls. For the remainder of the trial, capons and controls generally demonstrated comparable growth rates, as noted for the fourth week. Meanwhile, the hormonized birds continued to gain at a rate superior to either of the other groups.

For all birds, the rate of gain for the fifth week of the trial was much less than for the previous week. This may have been caused by the unusually hot weather experienced during this period and the fact that the birds were recovering from an encounter with chronic respiratory disease. It was noted, however, that control birds appeared to be less affected than the treated birds.

Table 1. Effect of caponization and estradiol-17β-monopalmitate on the rate of gain, feed efficiency and dressing percentage of broilers.

Treatment	Capon	Caponette	Control
Gain 4-5 weeks of age (g)	128	193	195
Feed-gain ratio	2.76	2.37	2.37
Gain 5-6 weeks of age (g)	195	224	215
Feed-gain ratio	2.43	2.38	2.55
Gain 6-7 weeks of age (g)	221	252	210
Feed-gain ratio	2.49	2.72	2.69
Gain 7-8 weeks of age (g)	251	282	251
Feed-gain ratio	2.59	2.79	2.75
Gain 8-9 weeks of age (g)	204	209	221
Feed-gain ratio	3.35	3.54	3.10
Gain 9-10 weeks of age (g)	272	243	270
Feed-gain ratio	2.63	2.98	2.99
Gain 10-11 weeks of age	110	113	141
Feed-gain ratio	6.90	6.78	5.36
Gain 4-11 weeks of age (g)	1,381	1,516	1,503
Feed-gain ratio	3.07	3.10	3.00
Live weight -- 11 weeks (g)	1,740	1,878	1,869
Eviscerated weight (g)	1,409	1,516	1,478
Dressing percent	80.97	80.72	79.08

A comperison of the rates of gein shows that for 3 weeks efter treatment, hormonized birds gained as much as 30 g more per bird per week than either controls or capons. However, the last 3 weeks of the experiment they gained at rates equal to or less than the capons and controls. The failure of caponettes to continue the extra gains may be because the Kansas State University grower ration is 17 percent protein, end Mattox and Moore, Inc., recommends thet for maximum results to be obtained from the estradiol-17β-monopalmitate injection, a ration of 14 percent protein and high cerbohydrate content should be fed during this period.

The final weight of the birds was recorded after they had been starved in preparation for slaughter. Therefore, the total weight gain indicated is slightly less than was actually gained. The total weight gain for caponettes was only slightly more than for controls. Both gained approximately 130 g more during the experiment than did the capons. The greatest weekly difference being during the first week.

Feed efficiency was decreased slightly by the hormonization and caponization treatments. Capons generally had the best feed efficiency except for the first and last weeks of the experiment.

The dressing percentage was based on the starved weight of the live birds. Treated birds had a significantly higher dressing percentage than control birds (Table 2). This wes attributed to a greater finish on the treated birds. It wes noted that the capons and caponettes exhibited greater fat deposits over the entire carcass. There was little difference in dressing percentege between capons and caponettes. This was in contrest to the pilot project in which the dressing percentages were 75.27 and 76.73 for capons and caponettes, respectively.

Table 2. Analysis of variance of dressing percentage of capons, caponettes, and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	9.12	3.77*
Individual	57	2.42	
Total	59		

*Significant at 0.05 level of probability.

Because of the lower dressing percentage for controls, their eviscerated weight was noticeably less than caponettes even though there was little difference between live weights.

The data presented in Table 3 shows the effect of caponization and estradiol-17β-monopalmitate on the fat content of light meat, dark meat and liver. The fat content of light meat was approximately the same for capons and caponettes. Both were significantly greater than the fat content of the light meat of control birds (Table 4).

The fat content of dark meat was greatest for capons and least for controls with the fat content of caponettes midway between these two. The percentage of fat in dark meat was significantly greater for capons than for control birds (Table 5).

Liver from caponettes contained a slightly higher amount of fat than did liver from capons. Both contained significantly greater fat content than liver from control birds (Table 6).

The effect of caponization and hormonization on the percentage of moisture in light meat, dark meat and liver is presented in Table 7. A significant decrease in moisture percentage of liver (Table 10) was found in both groups of treated birds. This was as expected since Andrews and Bohren (1947), Detwiler et al. (1950) and others have reported an inverse relationship between the percentage of fat and the percentage of moisture. This relationship was not always observed in the light and dark meat. The moisture percentage in light meat and dark meat samples was similar for capons and controls even though there was a significant difference in the percentage of fat in these samples. Data in the analysis of variance in Table 8 shows the lower moisture percentage in light meat of hormonized

Table 3. The effect of caponization and estradiol-17β-monopalmitata on the fat content of light meat, dark meat and liver.

Treatment	Capon	Caponette	Control
Light meat (%)	0.75	0.770	0.43
Dark meat (%)	4.41	4.02	3.62
Liver (%)	2.84	2.96	2.41

Table 4. Analysis of variance of the percentage of fat in light meat of capons, caponettes and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.48	3.44*
Day	7	0.21	1.51
DXT	14	0.09	0.64
Within	24	0.14	
Total	47		

*Significant at 0.05 level of probability.

Table 5. Analysis of variance of the percentage of fat in dark meat of capons, caponettes and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	7.92	6.29**
Day	7	1.69	1.34
DXT	14	0.41	0.33
Within	24	1.26	
Total	47		

**Significant at 0.01 level of probability.

Table 6. Analysis of variance of percentage of fat in liver of capons, caponettes and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	1.48	6.17**
Day	8	0.46	1.92
DXT	16	0.23	0.96
Within	27	0.24	
Total	53		

**Significant at 0.01 level of probability.

Table 7. Effect of caponization and estradiol-17β-monopalmitate on the percentage of moisture in light meat, dark meat and liver.

Treatment	Capon	Caponette	Control
Light meat (%)	74.45	73.45	74.37
Dark meat (%)	74.13	73.17	74.49
Liver (%)	73.02	73.68	75.07

Table 8. Analysis of variance of the percentage of moisture in light meat of capons, caponettes and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	6.20	5.17**
Individual	57	1.20	
Total	59		

**Significant at 0.01 level of probability.

birds was significant. Data in Table 9 indicates a significantly lower moisture percentage in dark meat of hormonized birds than in capons and controls.

Average thawing loss, cooking loss, and cooking time for each treatment is presented in Table 11. Essentially no difference was observed in thawing loss percentage among carcasses from different treatments (Table 12).

Cooking time was approximately the same among the different groups. The great amount of variation within treatments, as indicated in Table 14, was probably caused by the technique used to determine cooking time. The location of the meat thermometer within the breast muscle and removal of the chicken from the oven exactly when the end point temperature was reached were important factors but subject to great variation.

The cooking loss percentage was least for capons and greatest for caponettes. The difference was not significant (Table 13).

The effect of caponization and estradiol-17β-monopalmitate on juiciness, tenderness and flavor of cooked, light and dark meat is presented in Table 15. No significant differences were noted by the taste panel for these organoleptic factors (Tables 16, 17, 18, 19, 20 and 21). Controls, however, received consistently lower scores than capons and caponettes for all factors except flavor of dark meat. There was a tendency for some individuals of the taste panel to prefer birds from a certain group.

Table 22 shows the overall preference by rank for cooked light and dark meat. This table reflects the same trends in acceptability that were shown in Table 15. Overall preference differences were also nonsignificant.

Table 9. Analysis of variance of the percentage of moisture in dark meat of capons, caponettes and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	9.39	3.49*
Individual	57	2.69	
Total	59		

*Significant at 0.05 level of probability.

Table 10. Analysis of variance of the percentage of moisture in liver of capons, caponettes and control birds.

Source of variation	D.F.	Mean square	F value
Treatment	2	21.93	6.57*
Individual	57	3.34	
Total	59		

*Significant at 0.05 level of probability.

Table 11. The effect of caponization and estradiol-17β-monopalmitate on thawing loss, cooking loss and cooking time.

Treatment	Capon	Caponette	Control
Thawing loss (%)	5.99	5.76	5.90
Cooking loss (%)	20.71	22.66	21.94
Cooking time (min/lb)	57.80	57.54	57.05

Table 12. Analysis of variance of thawing loss of capon, caponette and control carcasses.

Source of variation	D.F.	Mean square	F value
Treatment	2	19.43	0.08
Day (Sample)	9	218.38	2.05
Error	18	90.21	
Total	29		

Table 13. Analysis of variance of cooking loss of capon, caponette and control carcasses.

Source of variation	D.F.	Mean square	F value
Treatment	2	9.72	1.94
Day	9	25.26	4.83
Error	18	5.01	
Total	29		

Table 14. Analysis of variance of cooking time of capon, caponette and control carcasses.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.13	0.003
Day	9	281.96	6.35
Error	18	44.35	
Total	29		

Table 15. Effect of caponization and estradiol-17β-monopalmitate on juiciness, tenderness and flavor of cooked light and dark meat.*

Treatment	Capon	Esmopal	Control
Juiciness			
Light meat	3.97	3.97	3.77
Dark meat	4.72	4.59	4.56
Tenderness			
Light meat	4.29	4.39	4.19
Dark meat	5.06	4.92	4.87
Flavor			
Light meat	4.57	4.46	4.34
Dark meat	4.34	4.66	4.59

*Rank of 1-7 (least desirable-most desirable).

Table 16. Analysis of variance of juiciness of cooked light meat of capons, caponettes and control broilers.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.13	1.08
Day	9	0.50	4.16
Error	18	0.12	
Total	29		

Table 17. Analysis of variance of juiciness of cooked dark meat of capons, caponettes and control broilers.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.065	0.72
Day	9	0.16	1.77
Error	18	0.09	
Total	29		

Table 18. Analysis of variance of tenderness of cooked light meat of capons, caponettes and control broilers.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.10	0.22
Day	9	0.76	1.77
Error	18	0.45	
Total	29		

Table 19. Analysis of variance of tenderness of cooked dark meat of capons, caponettes and control broilers.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.01	1
Day	9	0.26	1.34
Error	18	0.19	
Total	29		

Table 20. Analysis of variance of flavor of cooked light meat of capons, caponettes and control broilers.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.14	2.37
Day	9	0.25	4.23
Error	18	0.059	
Total	29		

Table 21. Analysis of variance of flavor of cooked dark meat of capons, caponettes and control broilers.

Source of variation	D.F.	Mean square	F value
Treatment	2	0.28	1.27
Day	9	0.28	1.27
Error	18	0.22	
Total	29		

Table 22. Effect of caponization and estradiol-17β-monopalmitate on overall preference rank of cooked light and dark meat.*

Treatment	Capon	Caponette	Control
Light meat	2.02	1.92	2.05
Dark meat	1.99	1.98	2.02

*Rank of 1-3 (most desirable-least desirable).

Table 23. Analysis of variance by rank of overall preference of light and dark meat of capons, caponettes and control broilers.

Treatment	Capon	Caponette	Control	X^2_r
Light meat	18	20.5	21.5	0.65ns
Dark meat	19.5	21	19.5	0.15ns

ns Nonsignificant.

SUMMARY AND CONCLUSIONS

A study was conducted to compare the effect of caponization and estradiol-17β-monoplamitate injection on production efficiencies, yields, chemical composition and organoleptic quality of chicken broilers.

At 26 days of age, 300 commercial, Cobb Strain, male chickens were randomly separated into three groups: capons, caponettes and controls. The capon group was starved for 24 hours then surgically caponized. At 35 days of age, each bird in the caponette group was injected subcutaneously at the base of the skull with 10 mg of estradiol-17β-monopalmitate.

Kansas State University 21 Percent Protein Chick Starter Ration was fed from 1 day of age to 5 weeks of age. Kansas State University 17 Percent Protein Chick Grower Ration was fed from 5 weeks of age to 11 weeks of age. Feed and water were fed ad libitum. The birds were reared on the floor throughout the experiment. Feed consumption, mortality and individual body weights were recorded weekly.

At 11 weeks of age all birds were processed. Randomly selected carcasses were cut into halves for further study. The right halves were sealed in plastic bags, frozen and held at 0° F until used for organoleptic evaluation. The left halves were analysed for moisture and fat content of the pectoralis major muscle (light meat), and composite thigh muscle (dark meat) and liver.

For organoleptic evaluation, the carcass halves were thawed then cooked at 325° F to an internal breast temperature of 185° F. During each cooking period, one-half carcass from each treatment was cooked. A one-half inch cube of thigh meat and a one-half inch cube of breast meat from

each bird were given to each member of a taste panel for organoleptic evaluation. Light meat and dark meat were scored separately for juiciness, tenderness, flavor and overall preference.

The data were analyzed statistically and the following conclusions were made concerning this study:

Caponettes gained only slightly more weight than controls. Both gained significantly more weight than capons.

Feed efficiency was approximately the same for capons, caponettes, and controls. Controls had a slightly more favorable feed efficiency than treated birds.

Dressing percentage was approximately the same for capons and caponettes. Both had a significantly higher dressing percentage than controls.

Caponettes averaged a higher eviscerated weight than capons and controls. Capons averaged the lowest eviscerated weight.

The fat content of light meat, dark meat and liver was significantly increased by caponization and estradiol-17β-monopalmitate.

The moisture content of light meat and dark meat was significantly decreased by estradiol-17β-monopalmitate. Moisture content of liver was significantly decreased by caponization and estradiol-17β-monopalmitate.

Thawing loss, cooking loss and cooking time were not affected by the caponization and hormonization treatments.

Although treated birds consistently received slightly higher scores for juiciness, tenderness and flavor, the differences were not significant. Treated birds averaged a more desirable overall preference rating than controls. There was a tendency for some individuals of the taste panel to prefer birds from a certain group.

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APPENDIX

Table 1. Kansas State University 21 Percent Protein Chick Broiler Starter Ration.

Fed 0-5 Weeks of Age

Ingredients Used	Per 100 Lbs.
Corn, ground, yellow	30.00 "
Sorghum grain, ground	31.00 "
Alfalfa meal, dehydrated, 17% protein	2.00 "
Soybean oil meal, solvent extracted, 44% protein	29.00 "
Fish meal, 60% protein	4.00 "
Soluferm-500 (R) (Fermentation residue)	1.50 "
Calcium carbonate (Limestone)	1.00 "
Dicalcium rock phosphate	1.00 "
Salt (Sodium chloride)	0.50 "
Total	100.00 lbs.

Added per 100 Lbs.	
Trace mineral mix	23 grams
Vitamin A (10,000 USP units/gram)	10 "
Vitamin D_3 (15,000 ICU/gram)	5 "
B-Complex vitamin mix	23 "
Methionine (Feeding grade)	23 "
Vitamin B_{12} mix (20 mg/lb.)	10 "
Choline Chloride - 25% mix	40 "
Coccidiostat	23 "
Antibiotic supplement	23 "

(R) = Registered trade mark.

Table 2. Kansas State University 17 Percent Protein Broiler Finisher Ration.

Fed 5 Weeks of Age to Market

Ingredients Used	Per 100 Lbs.
Corn, yellow, ground	34.50 "
Sorghum grain, ground	35.00 "
Alfalfa meal, 17% protein, dehydrated	1.00 "
Soybean oil meal, 44% protein, solvent	27.00 "
Calcium carbonate	1.00 "
Dicalcium phosphate	1.00 "
Salt	0.50 "
Total	100.00 lbs.

Added per 100 Lbs.	
Trace mineral mix	23 grams
Vitamin A (10,000 USP units/gram)	10 "
Vitamin D_3 (15,000 ICU/gram)	5 "
B-complex water soluble vitamin mix	23 "
Methionine	23 "
Vitamin B_{12} mix (20 mg/lb.)	10 "
Choline Chloride, 25% mix	40 "
Coccidiostat	23 "

Table 3. Score card used for organoleptic evaluation of light and dark meat of broilers.

	Factor*			
Sample No.	Juiciness	Tenderness	Flavor	Comments

*Scoring Key:

7 - Very desirable
6 - Moderately desirable
5 - Slightly desirable
4 - Acceptable
3 - Slightly undesirable
2 - Moderately undesirable
1 - Very undesirable

Overall Preference Rank

1.
2.
3.

THE EFFECT OF CAPONIZATION AND ESTRADIOL-17β-MONOPALMITATE ON PRODUCTION, CHEMICAL COMPOSITION AND ORGANOLEPTIC QUALITY OF BROILERS

by

LAWRENCE ROGER YORK

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A study was conducted to compare the effect of caponization and estradiol-17β-monoplamitate injection on production efficiencies, yields, chemical composition and organoleptic quality of chicken broilers.

At 26 days of age, 300 commercial, Cobb Strain, male chickens were randomly separated into three groups: capons, caponettes and controls. The capon group was starved for 24 hours then surgically caponized. At 35 days of age, each bird in the caponette group was injected subcutaneously at the base of the skull with 10 mg of estradiol-17β-monopalmitate.

Kansas State University 21 Percent Protein Chick Starter Ration was fed from 1 day of age to 5 weeks of age. Kansas State University 17 Percent Protein Chick Grower Ration was fed from 5 weeks of age to 11 weeks of age. Feed and water were fed ad libitum. The birds were reared on the floor throughout the experiment. Feed consumption, mortality and individual body weights were recorded weekly.

At 11 weeks of age all birds were processed. Randomly selected carcasses were cut into halves for further study. The right halves were sealed in plastic bags, frozen and held at 0° F until used for organoleptic evaluation. The left halves were analyzed for moisture and fat content of the pectoralis major muscle (light meat), and composite thigh muscle (dark meat) and liver.

For organoleptic evaluation, the carcass halves were thawed then cooked at 325° F to an internal breast temperature of 185° F. During each cooking period, one-half carcass from each treatment was cooked. A one-half inch cube of thigh meat and a one-half inch cube of breast meat from each bird were given to each member of a taste panel for organoleptic

evaluation. Light meat and dark meat were scored separately for juiciness, tenderness, flavor and overall preference.

The data were analyzed statistically and the following conclusions were made concerning this study:

Caponettes gained only slightly more weight than controls. Both gained significantly more weight than capons.

Feed efficiency was approximately the same for capons, caponettes, and controls. Controls had a slightly more favorable feed efficiency than treated birds.

Dressing percentage was approximately the same for capons and caponettes. Both had a significantly higher dressing percentage than controls.

Caponettes averaged a higher eviscerated weight than capons and controls. Capons averaged the lowest eviscerated weight.

The fat content of light meat, dark meat and liver was significantly increased by caponization and estradiol-17β-monopalmitate.

The moisture content of light meat and dark meat was significantly decreased by estradiol-17β-monopalmitate. Moisture content of liver was significantly decreased by caponization and estradiol-17β-monopalmitate.

Thawing loss, cooking loss and cooking time were not affected by the caponization and hormonization treatments.

Although treated birds consistently received slightly higher scores for juiciness, tenderness and flavor, the differences were not significant. Treated birds averaged a more desirable overall preference rating than controls. There was a tendency for some individuals of the taste panel to prefer birds from a certain group.