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To the Graduate Council:

I am submitting herewith a thesis written by Emmanuel D. Tebong entitled "A Comparative Study of Photoperiods and Housing Systems in Broiler Production." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Poultry.

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A COMPARATIVE STUDY OF PHOTOPERIODS AND HOUSING SYSTEMS IN BROILER PRODUCTION

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Emmanuel D. Tebong

August 1972

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ABSTRACT

Two experiments were conducted to compare the performance of broilers on litter, wire floor, and in cages with and without light.

Three-hundred and twenty birds were employed in each experiment. In Experiment I, there were four pens each of litter with light, litter without light, wire floor with light, and wire floor without light. The birds in Experiment II were in cages, half with and half without light.

Observations and measurements taken included body weight; feed consumption; mortality; breast blisters; keel, hock, and toe deformity; slipped tendon; rate of feathering; bone breaking strength; meat quality; and bird activity.

The weight of broilers reared in darkness in Experiment I was significantly higher than that of birds reared in light, but feed efficiency was superior for caged birds when compared with litter and wire floor birds.

The incidence of breast blisters was much higher among caged birds with the males more severely affected. Lighted birds in Experiment I had a highly significantly lower incidence of breast blisters when compared to birds reared in darkness.

Meat quality and bone breaking strength were neither effected by light regime nor by the housing systems.

Hock deformity was very pronounced in males; and the incidence of crooked toes was significantly higher among male birds in light.

Slipped tendon and keel deformity were highly significant among caged birds without light.

Mortality in all treatments was negligible.

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CHAPTER I

INTRODUCTION

Considerable interest already exists for raising broilers in cages. The high cost of and the shortage of litter in some areas; the greater bird density per unit area of birds in cages, and the shortage of farm labor for catching finished broilers appear to be the major forces behind cages for broilers; besides, of course, the possibility that disease and parasite problems might be reduced if broilers do not come into direct contact with their fecal matter.

But the major drawback to the use of cages at present is the high incidence of breast blisters associated with cages.

Conservative estimates place the loss due to breast blisters at 3 per cent of the total broilers raised. If this estimate is correct, then it must be a colossal loss to the industry to have 3 per cent of the 2.75 billion broilers raised in the United States in 1969 (Cathcart, 1971) and the 300 million raised in Britain in 1971 (Terry, 1971) down graded. Converting this loss into dollars will amount to several millions.

This situation can hardly be satisfactory in an industry whose costs of production are steadily rising and whose profit margins are constantly on the decline.

Lighting broiler houses has received a lot of attention in the past two decades, and several light regimes are recommended, but continuous light of low intensity is the most popular in the industry. Unpublished work at The University of Tennessee indicates possible advantages in

growing broilers in darkness. But growing broilers in darkness will be such a radical change that it will take much convincing to sell the idea to the industry; besides, this new system may have a profound influence on other body characteristics: feathering, hock and toe deformities, keel bone, breast blister, and meat quality.

But if by growing broilers in cages without light can reduce the incidence of breast blisters and improve feed efficiency without jeopardizing meat quality and other body characteristics, then a problem of great concern to the broiler industry will begin to disappear.

CHAPTER II

OBJECTIVE

The objective of the experiments reported herein was to investigate the growing of broilers on wire and on litter, with and without light from the standpoint of growth rate, feed conversion, bone strength, rate of feathering, hock and toe deformity, and the quality (flavor, tenderness, and juiciness) of the meat.

CHAPTER III

LITERATURE REVIEW

Broilers in Cages

Poultry production in cages has been a huge success with layers (Bailey et al., 1959) but broiler production in cages is still undergoing experimental stages (Digest, 1972).

Atkins (1969) observed that where caged broilers were allowed half the floor space of a comparable group on litter, the caged birds were 16 gms. (.15 lb.) lighter, and converted feed slightly less satisfactorily. Hardin (1969) in a series of four trials concluded that feed conversion was poorer for caged birds, although Andrews (1971) found body weights comparable.

Howes (1969) lists advantages of cages for broilers as being more sanitary, better disease and dust proof, reducing manure bulk, and as facilitating catching. However, he then contends that the disadvantages may out-number the advantages: initial higher investment in housing, leg weakness, more bruises and breast blisters, and more problems with frequent manure removal.

Gerry (1971) working with broiler breeders on wire and slat floors found males having very bad feet (sores). But the severest problem with growing broilers in cages is the incidence of breast blisters. Several workers have suggested the use of wooden cage floors and plastic mats on the floor. Lloyd (1969) demonstrated that broilers weighing 1.71 Kg. and 1.81 Kg. reared on wire resulted in downgrading of 21.7 per cent and

27.3 per cent, respectively, due to blistering. Plastic coated wires reduced these levels to 9 per cent.

Working with different types of cage bottoms, Reed et al., (1966) demonstrated that the type of cage bottom used influenced the incidence of breast blisters. Wire bottoms and wire rods produced the highest number of breast blisters. They observed that covering the bottoms with soft material cut down on the incidence of blisters. Bradley et al. (1971) worked with four types of cage bottoms and three watering systems to determine growth rate, feed efficiency, market quality, and liveability of broilers. At 59 days of age the males averaged 1,667 grams while the females weighed 1,435 grams, and they found that approximately 9 per cent of these birds had some type of breast abnormality. Andrew (1971) conducted two experiments with broilers in cages. In the first he found that birds raised in plastic mesh had a higher incidence of breast blisters than those raised on litter; and in his second trial he observed more blisters with broilers grown on plastic mesh and less on both groups of birds raised on plastic mesh and a rubber-coated nylon and litter.

Yates and Brunson (1971) carried out a series of experiments to evaluate the quality of broiler carcasses as influenced by rearing in wire cages, plastic coops, and litter floors. They found the incidence of breast blisters was greater among cage reared birds. They also found bones of broilers reared on wire and in coops to be significantly poorer in quality by these criteria: bone breaking during processing, strength as measured by shear press, and per cent of ash content of bone. Lloyd (1972) has reported a new design in the use of plastic coops in which breast blisters or bruises are completely eliminated.

Welch et al. (1971) observed a higher incidence of breast blisters, perosis and bone deformities among caged birds when compared with floor broilers. Mortality was also higher in cage broilers. They also noted that colony size was positively correlated to the incidence of breast blisters and body weight.

Digest (1972) and Swift (1972) have reported the development in England of a broiler cage system using tension plastic floors which can hold birds to a weight of 2.14 Kg. without blisters.

Krosigk and Pirchner (1971) have suggested positive genetic correlations between production traits for cage versus litter management of leghorn type birds.

Photoperiodism in Broiler Production

The greatest advances in improving broiler performance have been made primarily by breeders, nutritionists and processors, but a big area where improvements can be made is in the bird's environment--temperature, light, air movements, and disease control. The influence of light on growth of pullets and the performance of layers has been extensively studied by Fairbanks (1924), Whetham (1933), Dobie et al. (1946), Mehrohof (1946), Ringrose (1952), Tomhave (1954), Platt (1955), Sykes (1956), Marr et al. (1956), Isaacks et al. (1958), Morris and Fox (1958 and 1960), King (1958, 1959, 1961, and 1962), Bowman and Archibald (1959), Lert (1960), Yeates (1960), Dories et al. (1964), Noles and Smith (1964), Ingkasuwan and Ogasawara (1966), and Dirminey et al. (1970).

Previous experiments have shown that lighting may have an effect on growth and feed efficiency of broilers. Matson and Jensen (1956)

demonstrated with four broiler experiments that in every case the birds receiving continuous light grew at a faster rate than other birds receiving different lighting schedules. King (1965) showed that broilers grow faster during the first four weeks of age on 24 hours light per day than 6 hours of light per day, but earlier, Moore (1957) using intermittent lighting, found neither the amount nor the method of application of light having any effect on broiler growth. Clogg and Sanford (1951) found that better growth was obtained by using short light and dark periods instead of 12 hours of light followed by 12 hours of darkness, although the ratio of light to darkness was not altered. Moultrie et al. (1954) demonstrated that broilers given widely varying light schedules after six weeks of age had similar body weights at ten and twelve weeks of age. However, Shutze et al. (1959) and Dorminey (1971) concluded that differences in favor of continuous lighting was significant at marketing age and thereby confirmed the findings of other investigators that 12 hours of light followed by 12 hours of darkness led to inferior growth rates. Cherry and Barwick (1961) compared continuous darkness from seven days of age with near continuous light. They found that initial differences in body weight and food consumption in favor of continuous light disappeared after six weeks of age. Mean body weights and food conversion ratios at ten weeks were identical.

A number of workers have reported results obtained from growing broilers under different light intensities. Rider (1938), Wilson et al. (1956), Moreng et al. (1956) and Shutze et al. (1959) reported little differences between the growth of chicks under lights of different intensities. However, Barott and Pringle (1951) had earlier reported that

growth rate in the first eighteen days was slightly lower with light intensities greater than 6-foot candles. Cherry and Barwick (1961) studied light intensities intensively and concluded that the effect of intensity of light on broiler weight is slight, and that intensities greater than 1-foot candle are unnecessary and probably depress growth slightly. Intensities lower than 0.1-foot candle make routine operations in the broiler house difficult and may reduce labor efficiency. They also reported no significant differences in body weight or food consumption between intensities or colors of light at marketing age. Neither intensity nor color of light had any significant effect on mortality, but a higher incidence of breast blisters associated with less activity was found in birds at lower light intensities. However, Casey et al. (1969) found that in blue and green light, rate of sexual development was about the same, regardless of length of photoperiod. Foss and Arnold (1969) and Foss and Caren (1971) working with selected wavelengths, found maximum growth stimulation from the green region of the spectrum, and energy from the red portion best for stimulating reproductive development.

Seigel and Guhl (1956), Seigel et al. (1962), Seigel and Wood (1964) found that continuous illumination provided an advantage of increased feeding time for birds with a rapid growth potential. They obtained lower weights from birds under continuous light but with restricted feeding time than those fed ad libitum. Beane et al. (1964) found stock-light regime interaction to be unimportant with regard to body weight and none between light regime and feed efficiency. Skoglund et al. (1966) found that the 24-hour and 12-hour birds consumed more feed than 6- and 3-hour birds, but they found no evidence to indicate

differences in feed conversion. They concluded that a total of 12 hours of light will provide as efficient conditions for weight gain and feed efficiency in broilers as will 24 hours of day light.

Marr et al. (1971) found continuous illumination, 24 hours a day, contributed to poor feathering up to four weeks of age, although this apparent difference disappeared at nine weeks of age, but flattened cornea, and elongated eyelids was common among birds exposed to continuous illumination, with males being more susceptible.

Meat qualities of broilers grown under low light intensity were studied by Lloyd et al. (1969). Birds grown under low light intensity scored, on a live bird basis, lower than those grown under normal light, but this differentiation was difficult to determine on a dressed bird basis. Laboratory analysis showed no significant differences in protein, fat, moisture or fibre content between the two lots on different light regimes. They found also no cholesterol or dressing percentage differences, but the taste panel evaluations for seven quality factors easily selected the broilers grown under low light intensity over those grown under normal light intensity.

Light-temperature interaction in broilers has been demonstrated (Delton et al. 1970; Haller and Sunde, 1971). Under a high cyclic temperature condition, broilers reared under a continuous illumination gained significantly more when compared with those reared under 12 hours continuous light and 12 hours darkness.

Kraft and Howes (1962) studied the effect of light regimes on protein and energy requirements of broilers and found that there were no significant interactions between light and diet, nor did energy

level significantly affect growth rate.

The possibility of a relationship between light intensity in broiler houses and the incidence of feather picking and cannibalism has been suggested by Biester and Schwarte (1952) and Clear (1953). Feather picking and cannibalism are positively correlated with light intensity.

Breast Blisters

Breast blisters are cystic structures occurring on the ventral portion of the sternum of chickens and turkeys. May and Cox (1970) reported that the cyst is filled with viscous clear fluid which may turn dark in advanced cases. Blisters have neither a common characteristic, size, nor shape; some may not even be visible to the unaided eye.

At the processing station, breast blistered carcasses are trimmed; resulting in carcass downgrading as well as a loss of the trimmed meat. Crothers and Helbacka (1960) reported that breast blister was the second largest cause of downgrading in broilers.

Hodgon and Gutteridge (1941) studied the development of the breast blister. Working with day-old chicks having no evidence of breast blisters they later found spongy tissue in the skin of the keel area which later developed into breast blisters. Reporting on the same subject, O'Neil (1943) called the blister a true bursa since there was no evidence of a vesicle in the skin. O'Neil (1943) described the walls of the blisters as having white connective tissue, fibrous cartilage, mesenchyma tissue, and noted the lack of uniformity of the thickness of the walls of the cyst. Gresham and Barwick (1962) found purulent exudate in the cavity and described the cyst as lined by pink fleshy folds.

In 1968, McCune and Dellmann used the photomicrograph to study the process of breast blister development. Using day-old chicks with no evidence of synoval tissue, they found a slight degenerative process of tissue at two weeks of age. By the third week, the cyst could be observed. Lucas (1967) studied the same process of development and concluded that the breast blister resulted from some exterior irritation and not to a natural infectious process since leucocytes were rarely involved or found near the cavities. O'Neil (1943) also discovered that inner walls were poorly supplied with blood although the cysts were highly vascular.

Winget et al. (1958) induced breast blisters on broilers by both pressure and irritation to the keel. Its incidence and severity they concluded, are closely positively correlated to prolonged pressure and irritation. Reed and White (1966) confirmed these reports by subjecting the keel of broilers to friction for varying periods up to three hours but did not produce typical breast blisters. Prolonged pressure was not necessary, they concluded, to induce breast blisters.

The investigations of other workers, particularly those of Koonz et al. (1963); Adams et al. (1965); Dobson (1964 and 1966); McCure and Dellmann (1968); Reed et al. (1966); and O'Neil (1943) have clearly demonstrated that pressure on the keel is a prerequisite for the development of breast blisters.

Many other investigators have also shown that the incidence of breast blisters is positively correlated to both age and weight of the bird (Bird, 1944; Smith, 1956; Gyles et al. 1957; Bezanson et al., 1958; Winget et al., 1958; Stephenson et al., 1960; and May and Noles, 1965).

Hodgson and Guttridge (1941) found no significant influence of weight on breast blister development but three years later, Bird (1944) successfully demonstrated that birds developed breast blisters only when they attained a weight of 1,200 grams.

Susceptibility to breast blisters resulting from genetic variability has been demonstrated by Bird (1944). He found birds with greater body depth more susceptible to breast blisters. The works of Gyles et al. (1957) showed a positive correlation between the breast angle measurements and the incidence of breast blisters. The same workers estimated the heritability for breast blister condition in two lines of white Plymouth Rocks to range from 16 to 24 per cent in the blister line, and 0 in the non-blister line.

Hodgson and Gutteridge (1941) and Kondra and Cavers (1946) reported that American breeds, Light Sussex and Cornish males were more prone to breast blisters than the Mediterranean breeds. Leghorn males developed no breast blisters at all (Hodgson and Gutteridge, 1941; and Oneil, 1944).

The effect of feathering was demonstrated by Kondra and Cavers (1947) who showed that early feathering Barred Plymouth Rocks had significantly lower incidence of breast blisters than slow feathering strains. Funk and Savage (1956) found that birds with a natural lack of breast feather coverage had a higher incidence of breast blisters. The same results were obtained with birds whose breast feathers were plucked.

All investigators are agreed that sex has a definite bearing on incidence of breast blisters, with males more prone to this condition. Gyles et al. (1957) working with both sexes of the same weight observed

a greater incidence of breast blisters among males. The results of Bezanson and Stephenson (1958) confirmed the results of the previous investigators.

Siegel et al. (1957) found females feathering earlier than males and they maintained that the differences in the sexes may be associated with earlier feathering. Hodgson and Gutteridge (1941) failed to see the practical application of the heritable traits associated with breast blisters to practical breeding conditions because the genotype of the male is so complex. He believes that environmental and physical factors affecting the incidence of breast blisters should be employed.

Studying the incidence of breast blisters as related to the kind and quality of litter, Smith (1956) concluded that the incidence of blisters was higher in flocks raised on coarsely ground corn cobs, saw dust or shavings. Stephenson et al. (1960) worked with shavings, rice hulls, and straw and found no difference in the percentage of blisters for birds reared on each kind of litter. Bezanson and Stephenson (1958) observed that a greater depth of litter reduced but did not eliminate breast blisters. May and Noles (1965) observed that wetting the litter greatly increased the incidence of breast blisters.

Gyles et al. (1961) and Wisman et al. (1961) found crowding a major factor affecting the incidence of breast blisters. Shoffner and Canfield (1957) found roosts to significantly increase the incidence and Wisman and Beane (1965) working with no roosts, found less blisters at eleven weeks and none at all at nine weeks of age.

There was no significant difference in breast blisters among birds raised under continuous and natural lighting (Wisman and Beane, 1965).

Type of feeders have been investigated by Gyles et al. (1961) and Wisman and Beane (1965). They found no differences in the incidence of breast blisters between trough or tube feeders.

Bone Fragility

Bone fragility often results in bone breakage during processing (Rowland et al., 1968a) causing downgrading of poultry carcass. Working with pullets, Taylor and Moore (1954) observed that the percentage of bone ash of pullets dropped when placed on a low calcium diet. Jones et al. (1965) reported increased blood calcium with the administration of dienestrol diacetate, but Fry and Stadelman (1958) found no significant increase in the bone ash of growing broilers with the administration of diethylstilbestrol.

Rowland et al. (1968b) stated that hens kept in cages exhibit greater bone fragility during processing, and that floor birds do not show this condition; but Adams et al. (1968) reported the bone breaking strength of caged birds to be slightly higher than those of birds maintained on litter. Rowland et al. (1968b) failed to increase the breaking strength by increasing the phosphorus content of the diet. These workers also found the breaking strength of bones from roosters raised on litter to be significantly greater than those given similar treatment in cages. They therefore concluded that bone fragility problem is not a function of calcium depletion alone.

Lloyd et al. (1970) observed a 22.2 per cent bone breakage from broilers raised in plastic coops as compared with 8.6 per cent from those raised on litter. Trueta (1968) suggested that lack of muscular activity

may be a major factor in the development of osteoporosis in humans. Birds raised on wire floors were observed by Rowland and Harms (1970) not to decrease in both tibia ash or tibia breaking strength, but they found breaking strength of tibia reduced for hens raised in cages.

The results of the latest work by Rowland et al. (1971) contradict previous findings on the subject. They found no statistical difference in the breaking strength of bones from birds grown in batteries and floor; although one of their experiments deviated from the trend to show breaking strength of battery grown birds to be significantly lower than floor grown broilers. But they maintain this difference resulted from the lower feed intake among caged birds due to the warm weather conditions.

Flavor, Juiciness, and Tenderness

Fry et al. (1965) reported fishy flavors in birds fed rations containing fish meal in excess of 1.5 per cent. The investigations of Carrick and Hange (1926), Asmundson (1938), Marble et al. (1938), Odland et al. (1955), and Hardin et al. (1964) showed significant flavor differences in broilers fed a combination of 1.5 per cent fish oil and 15 per cent fish meal. Weisburg (1956) reported improved flavor and juiciness of broiler meats fed dry milk solids. Brant et al. (1958), Honson et al. (1959), and Kahlenburg et al. (1961) found no significant flavor differences with broilers fed synthetic vitamins and minerals. Peterson et al. (1959) and Brant and Hanson (1962) demonstrated that flavor increased with the age of the broilers. Wells and Dawson (1966) found juiciness to be directly related to tenderness. Martini and

Goodwin (1971) reported a highly significant effect of group breeding upon cooked thigh tenderness. Goetz et al. (1962) found no flavor differences among carcass grades. No significant differences between diseased and non-diseased birds were observed by a test panel (Brant et al. 1967).

Pippen et al. (1954) and Pippen and Klose (1955) reported a decrease in flavor with chilling, but Hurley et al. (1958) found differences due to chilling medium but not to chilling time. McVicker et al. (1958) found that the addition of chlorine to chill water produced flavor differences in ready-to-cook birds. Carlin et al. (1957) showed that increased storage time led to decreased flavor. Cantrell and Hala (1971) reported a preference for fresh when compared to frozen chicken stored three and nine months, respectively. In 1959, Hanson et al. observed that the condition of frozen storage influenced the flavor stability of precooked frozen coated chickens, flavor changes being more rapid in the meat than the coating. Quick frozen broilers lost flavor after 51 days (Stewart et al., 1945). Storage time increased shear values and skin removal lowered it and improved tenderness (Love et al., 1972).

Hanson et al. (1959) observed that an inert atmosphere increased flavor stability of frozen chickens. Carlin et al. (1959) noted that packaging did not significantly affect the flavor scores of frozen broilers and May et al. (1966) confirmed this finding with their studies of chickens.

Carlin et al. (1959) reported that precooking before storage accelerated flavor changes in chicken meat with fishy or stale flavor, but Khan and Van den Berg (1965) found that precooked frozen chicken had

a longer shelf life for flavor than fresh frozen chicken.

Wyche and Goodwin (1971) observed that 24-hour-aged parts were more tender than zero aged parts. They also agreed that hot-cut parts had a higher shear value than chill cut parts. The biceps femoral was more tender than the pectoralis major. Their test panel members detected differences in tenderness for cut-up time, aging time, and size of bird.

Several food preparations influence flavor, juiciness, and tenderness. Steamed meat has a higher flavor than pressure cooked meat (Swickard et al., 1954). Shano and Davidson (1958) reported no significant differences in the flavor of chicken cooked by roast, rotisserie, or microwave methods. Lewis et al. (1967) found wood charcoal grilling produced more intense flavor than other treatments. Cooked dark meat was found to be more flavorful by Peterson et al. (1959), Kahlenburg and Funk (1961), and Lewis et al. (1958). Brand and Hanson (1962) and Fry et al. (1966) found light meat more flavorful.

CHAPTER IV

EXPERIMENTAL PROCEDURES

Experimental Animals

Six-hundred and forty day-old broiler type chicks (Vantress Arbor Acres Cross) were employed in these studies: 320 chicks for Experiment I and 320 for Experiment II.

Housing Facilities

Experiment I was housed in House C on Cherokee Farm, and Experiment II in two rooms in the Poultry Service Laboratory.

The cages and walls in the Poultry Service Laboratory were thoroughly washed down, and all crevices through which light penetrated were sealed. All light bulbs in the dark room were taken out. In the other room which was to have light, three new forty-watt bulbs were put in, two on a time switch to come on at 6 a.m. and go off at 6 p.m., and one to stay on all the time.

In House C all light bulbs were taken out from the appropriate dark rooms and two new bulbs, forty watts and eight watts, respectively, were put in the appropriate lighted rooms. The forty-watt bulbs were on an automatic time switch to come on at 6 a.m. and go off at 6 p.m., while the eight-watt bulbs remained lighted throughout.

Papers (drop cloth) were placed on all wire floors to prevent the day-old chicks from falling through the wire for the first four days.

Two days before the arrival of the chicks, all heaters were turned on and the thermostats adjusted to maintain a uniform temperature of 35°C. at day old.

House C had sixteen pens, each approximately 150 cm. by 150 cm. of floor space. Both the heaters and the ventilation system were thermostatically controlled.

The two rooms used in the Poultry Service Laboratory have sixteen growing cages, each 60 cm. by 75 cm. The brooding batteries had five levels, each electrically heated and controlled by thermostats.

Experimental Design

The day-old chicks for Experiment I were received on the morning of December 30, 1971, sexed, vaccinated for Newcastle and infectious bronchitis disease, debeaked, and assorted randomly into four treatment groups as follows:

Group	Housing	Hours of Light Per Day	No. of Birds Per Pen	No. of Pens	Total No. of Birds
A	Litter Floor	24	20	4	80
B	Litter Floor	0	20	4	80
C	Wire Floor	0	20	4	80
D	Wire	24	20	4	80

Two pens, each from groups B and C received light for the first five days in order to get the chicks started on feed and water, and the other two pens had no light whatsoever.

Those chicks for Experiment II arrived on January 6th, 1972, and were immediately debeaked and vaccinated for Newcastle and infectious

bronchitis diseases, but were not sexed. They were then assorted randomly into two treatment groups as follows:

Group	Housing	Hours of Light Per Day	No. of Birds Per Pen	No. of Pens	Total No. of Birds
A	Growing cages	0	10	16	160
B	Growing cages	24	10	16	160

Birds in group A had light for the first 24 hours to start the chicks on feed and water and after that they went into total darkness.

Composition of the Diet

Both experiments were on the same diet from day-old to slaughter. The all mash diet was as shown in Table I.

Weights and Identification

Before the birds were slaughtered at 55 days of age, they were individually weighed and scored for breast blisters, feathering, keel deformity, hock and toe deformity. Then the birds were wing and leg banded for identification purposes.

Scales used for scoring for the body defects were as follows: breast blister, 1 to 7; toe deformity, 1 to 5; crooked keel, 1 to 5; hock deformity, 1 to 5, feathering, 1 to 3; and slipped tendon, 1 to 2.

In each case 1 represents a normal condition in the bird and the highest number on the scale represents extreme abnormality.

TABLE I

COMPOSITION AND CALCULATED ANALYSIS OF THE BROILER DIET

Feedstuff	Per Cent of Total
Yellow corn	55.10
Alfalfa meal 17 per cent	2.50
Fish meal 65 per cent	5.00
Soybean meal 48.5 per cent	28.00
Yellow grease	3.50
Ground limestone	1.20
Def: rock phosphate	1.00
Mn. Sulphate	0.02
Salt	0.48
Vitamin Mix 6	0.60
Coccidiostate-Premix	2.50
DL Methionine	0.10
Calculated Analysis	
Crude Protein, per cent	25
Productive Energy, c./lb.	978
Calorie Protein ratio	39.1
Methionine, per cent	0.957
Cystine, per cent	0.347
Calcium, per cent	1.146
Phosphorus, per cent	0.663
Available phosphorus, per cent	0.430
Manganese, mg./lb.	31.3
Vitamin A, I.U./lb.	6688
Vitamin D, I.U./lb.	340
Riboflavin, mg./lb.	3.03
Niacin mg./lb.	27.97
Pantothenic acid, mg./lb.	5.76
Choline, mg./lb.	760.00

Processing of the Broilers

Before processing, the crops of the birds were emptied by starving over a fifteen-hour period. The temperature of the scalding water was carefully controlled at 77°C., and defeathering was accomplished by the use of mechanical pluckers. Cold water was used for chilling.

Before the birds were opened, they were examined and scored for the following defects: breast blisters, swollen hocks, broken bones, and torn flesh. Scales used for scoring were as reported on page 20.

Sampling for Organoleptic Tests

After sexing, ten male and ten female birds from each treatment were randomly picked, dressed, and carefully packaged in polyethylene bags and frozen for the tests of flavor, juiciness, and tenderness. No birds from Experiment II were preserved for these tests.

Sampling for Breaking Strength of Bones

Ten samples were randomly taken from each treatment of the two experiments. The right wings of cockerels only were taken for this purpose, and these were frozen and preserved.

Organoleptic Tests

A test panel consisting of seven members was involved in the test which was organized by the Department of Food Technology. Male birds only were used for the tests, but the female birds were used for two practice sessions. Both dark and white meat were given out for the tests which consisted of seven sessions. Scoring was done according to the score charts in Tables II.

TABLE II

GRADING CHART FOR ORGANOLEPTIC TESTS

Scale	Flavor	Juiciness	Tenderness
5	Very good	Very good	Very tender
4	Good	Good	Tender
3	Fair	Fair	Slightly tender
2	Poor	Poor	Slightly tough
1	Very poor	Very poor	Tough

Bone Breaking Strength

Ten male birds from each treatment were picked at random and the right wing of each bird severed. The humerus were defleshed after cooking for about five minutes in boiling water.

The force used to break each humerus was measured by the use of an Alo-Kramer shear press. An attachment was designed for use with the shear press which allowed the bone to be supported at both ends and the pressure to be applied to the mid-point of the humerus. The attachment provided a span of 3 cm. The humerus was supported near the ends, 1.5 cm. from the mid-point at which the force was applied.

A 45.45 Kg (100 lbs.) ring was used and the speed of the shear press was 2 cm. per second. The maximum force used to break each bone was read from the chart of the shear press recorder.

Analysis of Data

Data were statistically analyzed by analysis of variance (Snedecor, 1956); differences between the treatments were determined by Duncan's Multiple Range Test (1955).

CHAPTER V

RESULTS AND DISCUSSION

Body Weights

Body weight of the birds in Experiment I were significantly ($P < .05$) affected by treatment, sex, and treatment-sex interaction (Table III). However, sex of bird was the only significant source of effect on body weight in Experiment II (Table IV). Birds maintained in the dark in Experiment I were significantly ($P < .05$) heavier than birds maintained in a light environment (Table IV). This confirms results obtained by Hogg (1966) and Voitle (1969). The sex-treatment interaction may be explained by the increased weight advantage of the male birds reared in the dark environment.

The coefficient of correlation between sex and weight (Tables VII and VIII) shows a negative relationship. This is not in contradiction to the former explanation of sex, weight relationship, but may be explained by the coding of the variables in which males were identified with the figure 1 and females 2.

No weight advantage for neither wire nor litter was indicated when reviewed within either the light or darkness treatments. These results are consistent with the investigations of Atkins (1969) and Andrews (1971) who found body weights of broilers raised in cages and on floor comparable.

Breast Blisters

The analysis of variance for breast blister scores for both Experiments I and II is presented in Tables III and IV.

TABLE III

ANALYSIS OF VARIANCE FOR THE EFFECT OF TREATMENT ON PERFORMANCE OF BROILERS--EXPERIMENT I

Source	D.F.	Mean Squares						
		Body Weight	Feather Score	Breast Blister	Hock Score	Crooked Toe	Slipped Tendon	Keel Score
Treatment	3	85257.14*	2.54**	170.08**	10.64**	2.63**	0.14	0.92**
Pen	3	697761.75	0.95	7.77	0.74	0.88	0.09	0.10
Sex	1	7436672.43**	0.14	49.36**	6.59**	1.50*	0.42*	0.09
Treatment-Sex	3	217604.57**	-0.02	1.25	0.58	0.86*	0.08	0.07
Residual	296	22972.25	0.13	1.30	0.27	0.17	0.08	0.08

*P < 0.05.

**P < 0.01.

TABLE IV

ANALYSIS OF VARIANCE FOR THE EFFECT OF TREATMENT ON PERFORMANCE OF BROILERS--EXPERIMENT II

Source	D.F.	Mean Squares				
		Body Weight	Breast Blister	Hock Score	Crooked Toe	Slipped Tendon
Treatment	1	26437.13	3.93	2.51*	0.00	1.41**
Sex	1	7372635.92**	23.13**	24.18**	1.58*	0.43*
Treatment-Sex	1	39775.71	0.97	-0.73	0.15	0.46*
Residual	308	3481987.	0.17	0.65	0.33	0.06

*$P < 0.05$.

**$P < 0.01$.

TABLE V

MEAN VALUES FOR BODY CHARACTERISTICS--EXPERIMENT I

Treatment	N	Body Wt.-Gr.	Feather Score	Breast Blister	Hock Score	Crooked Toe	Slipped Tendon	Keel Score	Feed Conversion Ratio
Light and litter	80	1692.79[a*]	1.00[a]	1.36[a]	1.01[a]	1.11[a]	1.03[a]	1.00[a]	2.07[a]
Light and wire	80	1693.19[a]	1.14[a]	1.31[a]	1.26[b]	1.41[b]	1.11[a]	1.01[a]	2.14[a]
Dark and litter	80	1741.50[b]	1.09[a]	3.84[b]	1.80[c]	1.00[a]	1.03[a]	1.13[b]	2.07[a]
Dark and wire	80	1755.75[b]	1.41[b]	3.89[b]	1.68[d]	1.08[a]	1.05[a]	1.23[c]	2.06[a]
Overall means	320	1720.81	1.16	2.60	1.44	1.15	1.05	1.09	2.09
Sex									
Male	174	1860.45	1.18	2.96	1.57	1.21	1.09	1.11	-
Female	146	1554.38	1.14	2.17	1.28	1.08	1.01	1.08	-

*Mean values in the same column which are followed by different superscripts are significantly different.

TABLE VI

MEAN VALUES FOR BODY WEIGHT AND OTHER CHARACTERISTICS--EXPERIMENT II

Treatment	Sex	N	Body Weight	Feather Score	Breast Blister	Hock Score	Crooked Toe	Slipped Tendon	Keel Score	Feed Conversion Ratio
Darkness	Male	72	1776.54^{a*}	1.00^{a}	4.75^{a}	2.56^{a}	1.21^{a}	1.22^{a}	1.00^{a}	-
Darkness	Female	84	1498.27^{b}	1.00^{a}	4.06^{a}	2.01^{b}	1.11^{b}	1.07^{b}	1.00^{a}	-
Light	Male	80	1809.00^{a}	1.00^{a}	4.79^{a}	2.71^{a}	1.24^{a}	1.01^{b}	1.00^{c}	-
Light	Female	76	1472.61^{b}	1.00^{a}	4.41^{a}	2.16^{b}	1.05^{b}	1.00^{b}	1.00^{a}	-
Sex										
Males		152	1793.63^{a}	1.00^{a}	4.77^{a}	2.63^{a}	1.22^{a}	1.11^{a}	1.00^{a}	-
Females		160	1486.08^{b}	1.00^{b}	4.22^{b}	2.08^{b}	1.08^{b}	1.03^{b}	1.00^{a}	-
Darkness		156	1626.71^{a}	1.00^{a}	4.38^{a}	2.26^{a}	1.15^{a}	1.14^{a}	1.00^{a}	1.8^{a}
Light		156	1645.12^{a}	1.00^{a}	4.60^{a}	2.44^{b}	1.14^{a}	1.01^{b}	1.00^{a}	1.8^{a}
Overall means		312	1635.91	1.00	4.49	2.35	1.15	1.07	1.00	1.8

*Mean values in the same column which are followed by different superscripts are significantly different.

TABLE VII

SIMPLE CORRELATIONS AMONG TREATMENT EFFECTS AND BODY CHARACTERISTICS OF BIRDS FROM EXPERIMENT I

	2	3	4	5	6	7	8	9	10	11
Treatment (2)	1.00									
Pen (3)	0	1.00								
Sex (4)	-0.04	-0.14**	1.00							
Body Weight (5)	0.12*	0.02	-0.64**	1.00						
Feathering (6)	0.25**	0.18**	-0.05	0.04	1.00					
Breast Blister (7)	0.71**	0.07	-0.22**	0.33**	0.22**	1.00				
Hock Deformity *8)	0.46**	-0.11*	-0.22**	0.29**	0.16*	0.52**	1.00			
Crooked Toe (9)	-0.23**	0.17**	-0.15**	0.07	-0.04	-0.21**	-0.10	1.00		
Slipped Tendon (10)	-0.06	0.11	-0.16**	0.02	0.08	0.01	0.05	0.35**	1.00	
Keel Deformity (11)	0.30**	-0.05	-0.06	0.07	0.18**	0.23**	0.19**	-0.06	-0.03	1.00

*P $<$ 0.05.

**P $<$ 0.01.

TABLE VIII

SIMPLE CORRELATIONS AMONG TREATMENT EFFECTS AND BODY CHARACTERISTICS OF BIRDS FROM EXPERIMENT II

	1	2	3	4	5	6	7	8
Treatment (1)	1.00							
Sex (2)	-0.05	1.00						
Body Weight (3)	0.04	-0.64**	1.00					
Feathering (4)	0	0	0	1.00				
Breast Blister (5)	0.08	-0.21**	0.32**	0	1.00			
Hock Deformity (6)	0.11*	-0.33**	0.41**	0	0.29**	1.00		
Crooked Toe (7)	-0.006	-0.13*	0.11*	0	0.09	-0.04	1.00	
Slipped Tendon (8)	0.26**	-0.14**	-0.03	0	-0.003	0.09	0.01	1.00

*P < 0.05.

**P < 0.01.

In Experiment I there was a highly significant ($P < .01$) effect of treatment in favor of birds reared in light; but in Experiment II, although the difference was not significant, the incidence of breast blisters was lower in birds reared in darkness.

Sex differences were highly significant ($P < .01$) in both experiments, with the incidence of breast blisters being higher in males. This trend was consistent in all the replications (Table V, page 28). This result may be explained by the fact that males have a higher mean body weight and are therefore more prone to breast blisters (May and Nole, 1965).

The incidence of breast blisters in both experiments was positively and highly correlated with treatments, hock deformities, and body weight. The incidence of breast blisters increased with body weight, and confirm results of previous workers (Bird, 1944 and Smith, 1956). In Experiment I, the incidence of breast blisters was also highly and positively correlated with feathering.

In both experiments, breast blisters were highly and negatively correlated with sex, and in Experiment I, crooked toes were highly and negatively correlated with breast blisters.

Bone Breaking Strength

Bone breaking strength was determined for Experiment I only and the data obtained for the analysis of variance are illustrated in Table IX. Although there was no significant sex-treatment interaction for bone breaking strength, it may be observed that birds reared on litter and wire with light had approximately the same mean bone breaking

TABLE IX

ANALYSIS OF VARIANCE FOR EFFECT OF TREATMENT ON BONE BREAKING STRENGTH--EXPERIMENT I

Source	D.F.	Mean Square Bone Breaking Strength
Treatment	3	2.56
Residual	36	40.77

*P < 0.05.

**P < 0.01.

strength (Table X). Whereas the birds reared on wire in darkness had the highest mean bone breaking strength, the ones reared on litter in darkness had the lowest mean bone breaking strength. These differences though non-significant, confirm the observations made during the processing of the broilers where bone breakage was very slight in all treatments. These results are incompatible with those obtained by Rowland et al. (1968b) who found the bone breaking strength of roosters raised on litter to be significantly greater than those of birds raised in cages.

Feathering, breast blisters, and keel deformity were negatively correlated, though non-significant, with bone breaking strength (Table XI).

Meat Quality

The analysis of variance for the effect of treatment on the meat quality is presented in Table XII. Only males from Experiment I were used to determine the effect of treatment on meat quality. Flavor, juiciness, and tenderness were quality traits evaluated.

Analysis of variance indicated no significant ($P < .05$) effect of treatment on either flavor, juiciness, or tenderness. However, members of the panel tended to prefer flavor of birds reared on litter with light; but this treatment was also rated by the panel as the least tender. Birds raised on wire with light received the highest mean score for juiciness (Table XIII).

The dark meat was consistently scored higher for flavor, juiciness, and tenderness compared to the light meat with the exception of the birds reared on wire with light and on litter in darkness. The dark meat of these birds was scored lower for flavor than was the light meat.

TABLE X

MEAN VALUES OF BONE BREAKING STRENGTH--EXPERIMENT I

Treatment	N	Bone Breaking Strength
Light and litter	10	37.74[a]
Light and wire	10	37.71[a]
Dark and litter	10	36.89[a]
Dark and wire	10	38.08[a]
Overall means	40	37.60

[a]Mean values in the same column which are followed by different superscripts are significantly different.

TABLE XI

SIMPLE CORRELATION COEFFICIENTS BETWEEN BONE BREAKING STRENGTH AND OTHER CHARACTERISTICS--EXPERIMENT I

	Treatment	Sex	Body Weight	Feather Score	Breast Blister	Hock Deformity	Crooked Toes	Slipped Tendon	Keel Score
Bone breaking strength	-0.02	-0.05	0.21	-0.01	-0.06	0.02	0	0.18	-0.27

TABLE XII

ANALYSIS OF VARIANCE FOR EFFECT OF TREATMENT ON MEAT QUALITY--
EXPERIMENT I

Source	D.F.	Mean Squares					
		FLAVOR		JUICINESS		TENDERNESS	
		Meat Light	Dark Meat	Light Meat	Dark Meat	Light Meat	Dark Meat
Treatment	3	0.087	0.380	0.189	0.135	0.173	0.072
Residual	20	0.294	0.170	0.135	0.066	0.311	0.109

TABLE XIII

MEAN VALUES FOR MEAT QUALITY--EXPERIMENT I

Treatment	FLAVOR		JUICINESS		TENDERNESS	
	Light Meat	Dark Meat	Light Meat	Dark Meat	Light Meat	Dark Meat
Light and litter	4.04^{a*}	4.05^{a}	3.26^{a}	4.33^{a}	3.65^{a}	4.27^{a}
Light and wire	3.90^{a}	3.77^{a}	3.58^{a}	4.36^{a}	3.93^{a}	4.23^{a}
Dark and litter	3.82^{a}	3.44^{a}	3.20^{a}	4.05^{a}	3.81^{a}	4.38^{a}
Dark and wire	3.77^{a}	3.83^{a}	3.48^{a}	4.14^{a}	4.04^{a}	4.12^{a}

*Mean values in the same column which are followed by different superscripts are significantly different at the 0.05 per cent level of probability.

There was a significant ($P < .05$) negative correlation between breast blisters and the flavor of light meat. All other relationships were non-significant (Table XIV).

Hock Deformity

The analysis of variance data for hock deformity for both experiments are presented in Tables III and IV, pages 26 and 27, respectively. Hock deformities were highly significantly ($P < .01$) affected by both treatment and sex. Incidence of hock deformity was much higher in males in both experiments; but hock deformity and light interaction was inconsistent. In Experiment I, birds maintained in light tended to experience less hock deformity, whereas, in Experiment II, the incidence of hock deformity was much higher in birds maintained in light (Tables V and VI, pages 28 and 29, respectively).

Coefficients of correlation for hock deformity are reported in Tables VII and VIII, pages 30 and 31, respectively. Hock deformity was highly significantly ($P < .01$) correlated with body weight and breast blisters, and in Experiment I, treatment and feathering were highly significantly correlated, but treatment was only significantly ($P < .05$) correlated with hock deformity in Experiment I. Sex and hock deformity were highly significantly ($P < .01$) and negatively correlated, males being more seriously affected. This may be explained by the fact that males are heavier and exert a greater weight on the hocks.

Crooked Toes

The analysis of variance for crooked toes is presented in Tables III and IV, pages 26 and 27, respectively. Sex exhibited a highly

TABLE XIV

SIMPLE CORRELATION COEFFICIENTS FOR MEAT QUALITY AND OTHER CHARACTERISTICS

		Treatment	Sex	Body Weight	Feather Score	Breast Blister	Hock Score	Slipped Tendon	Keel Score
FLAVOR	Light Meat	-0.19	0.10	-0.23	0.22	-0.55*	-0.13	-0.12	0.22
	Dark Meat	-0.31	-0.24	0.10	0.16	-0.37	-0.37	0.14	-0.24
JUICINESS	Light Meat	-0.07	-0.26	0.29	0.06	0.10	-0.10	0.01	-0.14
	Dark Meat	-0.46	0.16	-0.14	-0.08	-0.15	-0.39	-0.17	0.05
TENDERNESS	Light Meat	0.15	0.09	0.28	0.08	-0.15	0.13	-0.26	0.22
	Dark Meat	-0.02	0.29	-0.08	-0.03	-0.28	0.01	-0.03	0.02

*$P < 0.05$.

significant ($P < .01$) influence on the incidence of crooked toes in both experiments. Treatment effect was highly significant ($P < .01$) in Experiment I with the incidence of crooked toes greater among birds reared in light compared to birds maintained in darkness (Tables V and VI, pages 28 and 29, respectively). Treatment-sex interaction effect on crooked toes was significant ($P < .05$) only in Experiment I.

Sex was highly and negatively ($P < .01$) correlated with crooked toes with the males being more prone to the development of crooked toes (Tables VII and VIII, pages 30 and 31, respectively). Treatment and breast blisters were highly ($P < .01$) and negatively correlated and pen highly ($P < .01$) positively correlated with crooked toes in Experiment I only, but crooked toes and breast blisters were positively correlated in Experiment II. The inconsistency exhibited here is difficult to explain.

Slipped Tendon

The analysis of variance for slipped tendon score is presented in Tables III and IV, pages 26 and 27, respectively. Treatment exhibited a highly significant ($P < .01$) influence on the incidence of slipped tendon in Experiment II, with the incidence of slipped tendon more pronounced in birds reared in darkness. Sex effect was significant ($P < .05$) in both experiments with males experiencing more slipped tendons; but treatment-sex interaction was significant only in Experiment II (mean scores Tables V and VI, pages 28 and 29, respectively).

The correlation coefficients between slipped tendon and other traits are reported in Tables VII and VIII, pages 30 and 31, respectively. Slipped tendon was highly ($P < .01$) negatively correlated with treatment

in Experiment II and with sex in both experiments. Crooked toe and slipped tendon were highly and positively correlated.

Keel Deformity

Treatment and keel deformity were highly significant in Experiment I (analysis of variance, Tables III and IV, pages 26 and 27, respectively). The incidence of keep deformity was higher in birds raised in darkness (tables of means, Tables V and VI, pages 28 and 29, respectively). Keel deformity was highly ($P < .01$) and positively correlated with treatment, feathering, breast blisters, and hock deformity in Experiment I (Table VII, page 30); whereas birds in Experiment II showed no signs of deformities of keel.

Feathering

Feathering in Experiment II was practically normal but there was a significant ($P < .05$) interaction between feathering and treatment in Experiment I (Table III, page 26). Birds on wire floor with light, when compared to other treatments were poorly feathered (Table IV, page 27).

Feed Consumption

Feed conversion figures are tabulated in Tables V and VI, pages 28 and 29, respectively. In Experiment I, feed conversion ratio for birds on litter floor with light, birds on wire floor in darkness, and birds on litter in darkness had practically the same feed consumption figures, with a feed efficiency ratio of 1:2.07. The birds on wire with light were less efficient in feed utilization, averaging 1:2.14. These results are consistent with observations made by Atkins (1969) and

Hardin (1969) in which they concluded that feed conversion was poorer for caged birds.

Feed efficiency was more remarkable in Experiment II where the ratio of conversion was 1:1.8 for both treatments. These results contradict those of Atkins (1969) and Hardin (1969) who found caged birds poor converters.

These results, however, must be taken with caution because a lot of feed wastage, especially for those treatments in the dark rooms cannot be adequately accounted for.

CHAPTER VI

SUMMARY

Two experiments were conducted to compare the performance of broilers on litter, wire, floor, and in cages with and without light.

Three-hundred and twenty birds were employed in each experiment. In Experiment I, 16 pens, each approximately 150 cm. by 150 cm. housed 20 broiler type birds to 55 days of age. There were four pens each of litter with light, litter without light, wire floor with light, and wire floor without light.

Thirty-two cages, each 60 cm. by 75 cm. holding 10 birds each were employed in Experiment II. Half the birds were in darkness and the other half received light for 24 hours.

Observations and measurements taken included body weight; feed consumption; mortality; breast blisters; keel, hock, and toe deformity; slipped tendon; rate of feathering; bone breaking strength; meat quality; and bird activity.

The weight of broilers reared in darkness in Experiment I was significantly higher than that of birds reared in light, but this difference was not exhibited in Experiment II, where the birds were grown in cages.

Feed efficiency was superior for caged birds when compared with litter and wire floor birds, but it is difficult to account for wastage, especially with those birds reared in darkness.

Broilers reared in cages exhibited a high incidence of breast blisters with the males more severely affected. Lighted birds in Experiment I had a highly significantly lower incidence of breast blisters when compared to birds reared in darkness.

Meat quality and bone breaking strength were neither affected by light regime nor by the housing systems.

Hock deformity was very pronounced in males, but the effects of photoperiod interaction were inconsistent. Birds in Experiment I reared in light were significantly less affected by light and vice versa in Experiment II.

The incidence of crooked toes was significantly higher among male birds reared in light.

Slipped tendon was highly significant among caged birds without light.

The incidence of keel defects was significantly higher among birds in cages without light.

Neither photoperiodism nor housing systems had any significant effect on meat quality.

Mortality in all treatments was negligible, and the few birds that died were mostly drowned or starveouts.

REFERENCES

REFERENCES

Adams, A. W., A. J. Kahrs, and C. W. Carlson. 1965. Relationship of several factors to the incidence of breast blisters in large type male market turkeys. Poultry Sci., 44:1347-1348.

Adams, R. L., R. B. Harvington, D. D. Jackson, C. C. Haugh, and W. J. Stadelman. 1968. Bone breakage and bone fragmentation in spent hens. Poultry Sci., 47:1651.

Andrew, L. D. 1971. A look at age rearing of broilers. Poultry Sci., 50:1545.

Asmundson, U. S., F. H. Jukes, H. M. Fyler, and M. L. Maxwell. 1938. The effect of certain fish meals and fish oils in the ration on the flavor of the turkey. Poultry Sci., 17:147.

Atkins, K. 1969. Foodstuffs. Report on University of Maryland Research, February 22, p. 57.

Bailey, B. B., J. H. Quisenberry, and J. Taylor. 1959. A comparison of performance of layers in cage and floor housing. Poultry Sci., 38:565.

Barott, H. G., and E. M. Pringle. 1951. Effect of environment on growth and feed and water consumption of chickens and the effect of light on early growth. J. Nutrition, 45:265-274.

Beane, W. L., P. B. Siegel, and H. S. Siegel. 1964. Light environment as a factor in growth and feed efficiency of meat-type chickens. Poultry Sci., 44:1009-1012.

Benzonson, J. M., and E. L. Stephenson. 1958. Factors affecting a breast blister condition in broilers. Poultry Sci., 37:1185-1187.

Biester, H. C., and H. H. Scharte. 1952. Diseases of Poultry. Third edition. Ames, Iowa: Iowa State University Press.

Bird, S. 1944. Relative body depth, an exciting cause for development of keel bursae in chickens. Sci. Agri., 24:591-599.

Bowman, J. C., and J. D. H. Archibald. 1959. Effect of controlled lighting on production characters in fowls. Nature, London, 183:1138.

Bradley, J. H., W. O. Cowley, and J. H. Quisenberry. 1971. Performance of broilers housed in cages with plastic bottomed cages. Poultry Sci., 50:1554-1555.

Brant, A. W., and H. L. Hanson. 1962. Age, sex, and genetic affects on poultry flavor. XIIth World's Poultry Congress Proceedings, p. 409.

Brant, A. W., H. Lineweaver, and H. H. Dawson. 1958. The flavor of modern type broilers. XIIth World's Poultry Congress Proceedings, p. 664.

Brant, A. W., W. W. Sadler, and H. Lewis. 1967. The influence of disease on sensory properties of poultry meat. Food Technol., 21:289.

Cantrell, D., and K. K. Hale. 1971. Effect of chilling methods and holding time on yields and tenderness of fowls. Poultry Sci., 50:1561.

Carlin, A. F., B. E. Hall, and H. W. Walker. 1957. Correlation between flavor and number of microorganisms associated with eviscerated chicken treated with chlortetrecycline. Food Technol., 11:572.

Carlin, A. F., R. M. V. Pangborn, O. J. Cotterill, and P. G. Homeyer. 1959. Effect of pre-treatment and type of packaging material on quality of frozen fried chicken. Food Technol., 13:557.

Carrick, C. W., and S. M. Hauge. 1926. The effect of cod liver oil upon flavor in poultry meat. Poultry Sci., 5:213.

Cassey, J. M., P. C. Harrison, J. D. Latshaw, and J. McGinnis. 1969. Effects of photoperiod and colored lights on the sexual maturity of domestic fowl. Poultry Sci., 48:1794.

Cherry, P., and M. W. Barwick. 1961. The effect of light on broiler growth. Br. Poultry Sci., 2:21-37; 41-49.

Clegg, R. E., and P. E. Sanford. 1951. The influence of intermittant periods of light and dark on the growth rate of chicks. Poultry Sci., 30:760-762.

Clerk, T. B. 1953. Cannibalism in poultry. West Virginia Agric. Exp. Station Cir. 88.

Crothers, J. L., Jr., and N. V. Helbacka. 1960. Evaluation of broiler grade defects by quality control methods. Misc. Publ. 226, Univ. of Maryland Ext. Service.

Davies, G. T., T. W. Wilcox, and A. F. Beeckler. 1964. Photoperiodism response of chickens. Poultry Sci., 43:805-857.

Deaton, J. W., F. N. Reece, and J. D. May. 1970. Temperature and light and broiler growth. Poultry Sci., 49:1593-1596.

Dobie, J. B., J. S. Carver, and J. Roberts. 1946. Poultry lighting for egg production. Wash. Agric. Exp. Station Bull. 471.

Dobson, D. C. 1964. Influence of range shelters and time of hatch on the incidence of breast blisters o n male turkeys. Poultry Sci., 43:1313.

Dobson, D. C. 1966. Influence of various management conditions on the incidence of breast blisters and staphococeal synovitis in large type male turkeys grown in bloth confinement and on range. Poultry Sci., 45:1080-1081.

Dorminey, R. W. 1971. Broiler performance as affected by varying light periods and intensities. Poultry Sci., 50:1572.

Dorminey, R. W., J. E. Parker, and W. H. McCluskey. 1970. Effect of light intensity in Leghorn Pullets during the development and laying period. Poultry Sci., 49:1657-1661.

Evans, T. 1971. U. K. spending on broiler campaign. Broiler Industry, February.

Fairbanks, F. L. 1924. Artificial illumination of poultry houses for winter egg production. Cornell Ext. Bull. 90.

Foss, D. C., and E. L. Arnold. 1969. Effects of selected wavelength of equal energy intensity on physiological development of cockerels. Poultry Sci., 48:1808.

Foss, D. C., and L. B. Carew. 1971. Effect of environmental light energy on physiological development of cockerels. Poultry Sci., 50:1571.

Fry, J. C., and W. J. Stadelman. 1958. The effect of sex, age and hormonization on ash content of chicken bones. Poultry Sci., 37:67- 69.

Fry, J. L., P. Van Walleghem, P. W. Waldroup, and R. H. Harms. 1965. Fish meal studies. 2. Effects of levels and sources of "fish flavor" in broiler meat. Poultry Sci., 44:1016.

Fry, J. L., P. W. Waldroup, E. M. Ahmed, and H. Lydick. 1966. Enzymytic tenderization of poultry meat. Food Technol., 20:952.

Funk, E. M., and J. E. Savage. 1956. The incidence of breast blisters as related to the amount of breast feathering. Poultry Sci., 35:1399-1400.

Gerry, R. W. 1971. Broiler breeder performance on wire and wood slat floors at various housing densities. Research in the Life Sci., 19:6.

Goertz, G. E., B. Weathers, and J. L. Fry. 1962. Cooking losses acceptability and edible yield of U. S. graded turkey hens. Food Technol., 16:128.

Gresham, G. A., and M. W. Barwick. 1962. Breast blisters in the broiler chick. Nature, London, 193:1306-1307.

Gyles, N. R., J. C. Gilbreath, and R. M. Smith. 1957. Incidence of breast blisters within and between different breeding groups of broilers. Poultry Sci., 36:1124.

Gyles, N. R., B. N. McPherson, and L. D. Andrews. 1961. The influence of type of eeder on breast blisters in broilers. Poultry Sci., 40:814-816.

Haller, R. W., and M. L. Sunde. 1971. Some effects of various light and heat regimes on growth and performances of young chicks. Poultry Sci., 50:1502.

Hanson, J. L., A. A. Campbell, A. A. Kraft, G. L. Gilpin, and A. M. Harkin. 1959. The flavor of modern--and old-type chickens. Poultry Sci., 38:1071.

Hanson, H. L., and L. R. Fletcher. 1958. Time-temperature tolerance of frozen foods. XII. Turkey dinners and turkey pies. Food Technol., 12:40.

Hardin, J. O., J. L. Milligan, and V. D. Sidwell. 1964. The influence of solvent extracted fish meal and stabilized fish oil in broiler rations on performance and on the flavor of broiler meat. Poultry Sci., 43:858.

Hodgson, G. C., and H. S. Gutteridge. 1941. A process report from Canada of research on breast blisters. U, S. Egg and Poultry Mag., 47:150-155, 192.

Hogg, Edd. 1967. Ophthalmacrosis of the chick. Unpublished Doctoral dissertation, The University of Tennessee, Knoxville.

Howes, J. R., B. C. Wormeli, and B. R. Steward. 1969. Cages as an environment for broilers. Poultry Sci., 48:822.

Hurley, W. C., O. J. Kahlenburg, E. M. Funk, L. G. Maharg, and N. L. Webb. 1958. Factors affecting poultry flavor. I. Inorganic constituents. Poultry Sci., 37:1436.

Ingkasuwan, P., and F. X. Ogasawara. 1966. The effect of light and temperature and their interaction on the semen production of white Leghorn males. Poultry Sci., 45:1199-1206.

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

Jones, J. E., J. R. Wilson, P. W. Waldroup, and R. H. Harm. 1965. Effect of estradiol upon oxytetracycline utilization as related to blood calcium. Proc. Soc. Exp. Bio. Med., 188:133-135.

Kahlenberg, O. J., and E. M. Funk. 1961. The cooking of fowl with various salts for precooked poultry products. Poultry Sci., 40:668.

Khan, A. W., and L. Van den Berg. 1965. Changes in chicken muscle protein during cooking and subsequent frozen storage, and their significance in quality. J. Food Sci., 30:151.

King, D. F. 1961. Effect of increasing, decreasing, and constant light treatments on growing pullets. Poultry Sci., 40:479-484.

King, D. F. 1962. Egg production of chickens raised and kept in darkness. Poultry Sci., 41:1499-1503.

King, D. F. 1965. Proper lighting in broiler house; key to overall profits. The Feed Bag, July, p. 24.

Kondra, P. R., and J. R. Cavers. 1947. Relation of the rate of feathering to the development of keel bursae. Poultry Sci., 26:83-85.

Koonz, C. H., E. G. Strandine, and R. E. Gray. 1963. A study of factors responsible for keel blisters in poultry. Poultry Sci., 42:1281.

Kraft, S. A., and J. R. Howes. 1962. The effects of two light regimes upon the protein and energy requirements of broilers. Poultry Sci., 42:1657.

Krosigh, C. M., and F. Pirchner. 1971. Genetic correlations between production rates for cage versus litter management. Poultry Sci., 50:1642.

Lert, P. J., W. O. Wilson, and S. A. Hart. 1960. Effect of restricted lighting of pullets on subsequent egg production. Poultry Sci., 39:1270.

Lewis, B. L., D. L. Harrison, and P. E. Sanford. 1958. Effect of zanthophyll on the palatability and fat stability of fresh and frozen Broad Breasted Bronze turkeys. Feed Res., 23:7.

Lewis, P. K., Jr., T. L. Goodwin, and K. L. Moss. 1967. Effect of charcoal broiling on the sensory characteristics of hamburger and chicken breasts. Food Technol., 21:1133.

Lloyd, R. What we know about growing broilers in cages. Poultry Digest, November.

Lloyd, R. 1972. Growing broilers in plastic coops. Southern Inter. Conf., January 6.

Lloyd, R., G. Chaloupka, and P. Sammelwitz. 1969. Meat qualities of broilers grown under low light intensity in windowless house. Poultry Sci., 48:1835-1836.

Lloyd, R., G. Chaloupka, and E. W. Walpe. 1970. Plastic coup system of raising broilers. Poultry Sci., 49:1407.

Love, E. B., R. C. Wyche, and T. L. Goodwin. 1971. Effect of skin removal, storage time, and freezing method on tenderness and rancidity of broilers. Poultry Sci., 50:1599.

Lucas, A. M. 1967. Breast blisters. Agri. Research, September.

Marble, D. R., J. E. Hunter, H. C. Enandel, and R. A. Dutcher. 1938. Fishy flavor and odor in turkey meat. Poultry Sci., 17:49.

Marr, J. E., J. L. Milligan, R. C. Eaton, and H. L. Wilke. 1957. Effect of controlled light during growth upon subsequent laying performance of chickens. Poultry Sci., 36:1138.

Marr, J. E., D. E. Green, and J. L. Williamson. 1971. Photoperiodism and broiler performance. Poultry Sci., 36:1601.

Martini, P. J., and T. L. Goodwin. 1971. Estimates of meat tenderness, color, total moisture and cooking losses in 8-week old chickens. 2. The effect of selected matings. Poultry Sci., 50:1600.

Matson, W. E., and L. S. Jensen. 1950. What is the best lighting schedule? Broiler Growing, December, p. 17.

May, K. N., W. R. Powell, and J. P. Hudspeth. 1966. A comparison of quality of fresh chicken packed in various containers. Ga. Agri. Sta. Bull. N.S. 168.

May, K. N., and R. K. Noles. 1965. Effect of hesperidin and litter moisture on growth and carcass defects of broilers. Poultry Sci., 45:844-845.

May, K. N., and C. J. Cox. 1970. Determining rates of bruising in commercial broilers. Poultry Sci., 49:1756-1757.

McCune, E. L., and H. D. Dellmann. 1968. Developmental origin and structural characters of "breast blisters" in chickens. Poultry Sci., 47:852-858.

McVicker, R. J., L. E. Dawson, W. L. Mallmann, S. Walters, and L. Jones. 1958. Effect of certain bacterial inhibitors on shelf-life of fresh friers. Food Technol., 12:147.

Moreng, R. E., R. L. Bryant, and D. G. Gosslee. 1956. Physiological reaction of chicks to limited light. Poultry Sci., 35:977-983.

Morris, T. R., and S. Fox. 1958. Light and sexual maturity in domestic fowl. Nature, London, 181:1453.

Moore, C. 1957. How much light do broilers need? Poultry Tribune, January, p. 19.

Moultrie, F., E. D. Mueller, and L. F. Payne. 1954. The effect of feathering of broiler chicks. Poultry Sci., 33:784-790.

Mountney, G. J., R. E. Branson, and W. C. Hurley. 1960. The effect of flavour of holding frozen chicken for selected periods. Poultry Sci., 39:287.

Noles, R. K., and R. E. Smith. 1964. Rearing and maintaining pullets on controlled lighting. Poultry Sci., 43:848-857.

Odland, L. M., H. L. Mayfield, and L. Page. 1955. The influence of palatability of certain grain combinations, fishsolubles, and vitamin B-12 aureomycin supplement in poultry rations. Poultry Sci., 34:822.

O'Neil, J. B. 1943. Morphology of the so-called "breast blisters." Poultry Sci., 22:457-458.

O'Neil, J. B. 1944. Influence of growth on development of breast blisters. The U. S. Egg and Poultry Mag., 50:212.

Pippen, E. L., A. A. Campbell, and J. V. Streeter. 1954. Flavor studies. Origin of chicken flavor. J. Agri. Food Chem., 2:364.

Pippen, E. L., and A. A. Klose. 1955. Effects of water chilling on flavor of chicken. Poultry Sci., 34:1139.

Platt, C. S. 1955. A study of the effect of restricted lighting on January hatched pullets. Poultry Sci., 34:1045.

Poultry Digest. 1972. British firm introduces cage broiler system. Poultry Digest, 31:238.

Reed, M. J., H. D. White, T. M. Houston, and K. N. May. 1966. The use of different types of cage bottoms to reduce breast blisters in battery reared broilers. Poultry Sci., 45:1418-1419.

Reed, M. J., and H. D. White. 1966. Physiomechanics of broiler chickens. Paper No. 66-347.

Ringrose, R. C. 1952. Mimeo Publication, Univ. of New Hampshire, June 16.

Rowland, L. O., B. L. Dawson, E. Ross, and R. H. Harms. 1971. Comparison of bone characteristics between floor and battery grown broilers. Poultry Sci., 50:1121-1124.

Rowland, L. O., H. R. Wilson, E. M. Ahmed, P. W. Waldroup, and J. L. Fry. 1968. Influence of various dietory factors on bone fragility of caged layers. Poultry Sci., 47:507-511.

Rowland, L. O., H. R. Wilson, J. L. Fry, and R. H. Harms. 1968. Comparison of bone strength of caged and floor layers and roosters. Poultry Sci., 47:2013-2015.

Rowland, L. O., R.H. Harms, H. R. Wilson, I. J. Ross, and J. L. Fry. 1967. Breaking strength of chick bones as an indication of dietary calcium and phosphorus adequacy. Proc. Soc. Exp. Biol. Med., 126:399-401.

Schano, E. A., and J. A. Davidson. 1958. A comparison of chicken cooked electronically with conventionally cooked chicken. Poultry Sci., 37:1239.

Shirley, H. V. 1971. Verbal communication.

Shoffner, R. N., and T. H. Canfield. 1957. Keel defects in males ranged with and without roosts. Poultry Sci., 36:445-446.

Shutze, J. V., L. S. Jensen, and W. E. Matson. 1959. The effect of lighting regimes on growth and subsequent egg production. Nature, 38:1246.

Siegel, P. B., and A. M. Guhl. 1956. The measurement of some diurnal rhythms in the activity of White Leghorn Cockerels. Poultry Sci., 35:1340-1345.

Siegel, P. B., J. V. Craig, and C. D. Mueller. 1957. Heritabilities, sex differences, and phenotype correlations for six feathering characteristics. Poultry Sci., 36:621-628.

Siegel, P. B., and G. W. Wood. 1964. Length of daily feeding time as an influence on growth digestive efficiency in young chickens. Poultry Sci., 43:1340-1345.

Siegel, P. B., W. L. Beane, and C. Y. Kramer. 1962. The measurement of feeding activity in chickens to eight weeks of age. Poultry Sci., 41:1419-1422.

Skoglund, W. C., C. J Wabeck, and D. H. Palmer. 1966. Length of light for maximum broiler weight. Poultry Sci., 45:1185-1189.

Smith, R. C. 1956. Kind of litter and breast blisters on broilers. Poultry Sci., 35:593-595.

Stephenson, E. L., J. M. Bezanson, and C. F. Hall. 1960. Factors affecting the incidence and severity of a breast blister condition in broilers. Poultry Sci., 39:1520-1524.

Stewart, G. F., H. L. Hanson, B. Lowe, and J. J. Austin. 1945. Effects of aging, freezing rate, and storage period on palatability of broilers. Food Res., 10:16.

Swift of Scarborough, Ltd. 1972. Broiler cage system in England uses "tension" plastic floor. Poultry Industry, April, p. 78.

Sykes, A. H. 1956. Short day length and egg production in the fowl. J. Agric. Sci., 47:429.

Taylor, T. G., and J. H. Moore. 1954. Skeletal depletion of hens laying on low calcium diet. Br. J. Nutrition, 8:112-124.

Tomhave, A. E. 1954. Influence of artificial light during rearing on the egg production of October hatched New Hampshire. Poultry Sci., 33:725.

Trueta, J. 1968. Studies of the development of decay of human frame. Philadelphia: W. B. Saunders Company.

Voitle, R. A. 1969. The development of orhthalmacrosis in the domestic chicken. Unpublished Doctoral dissertation, The University of Tennessee, Knoxville.

Weisberg, S. M. 1956. How milk products affect the eating quality of broilers. Broiler World, 4:16.

Welch, S. W., P. F. Metcalfe, and R. Wesley. 1971. Broilers in cages. World Poult. Sci. Ass., 27:132-142.

Whetham, E. O. 1933. Factors modifying egg production with special reference to seasonal changes. J. Agric. Sci., 23:383.

William, E. C. 1971. Changes in the poultry meat industry and projections for the decades ahead. World's Poult. Sci. J., 27:17.

Wilson, W. O., A. E. Woodard, and H. Abplanalp. 1958. The effect and after-effect of varied exposure to light on chicken development. Biol. Bull., 111:415-422.

Winget, C. M., A. H. Smith, and C. F. Kellyl. 1950. The effect of body weight on joint and skin disorders of domestic birds. Poultry Sci., 37:1253-1254.

Wisman, E. L., and W. L. Beane. 1965. Effect of some management factors on the incidence of breast blisters in heavy broilers. Poultry Sci., 44:737-741.

Wisman, E. L., W. L. Beane, W. R. Luckham, and E. O. Essary. 1961. Efficiency of growing broilers to heavier weights. Poultry Sci., 40:1705-1712.

Wyche, R. C., and T. L. Goodwin. 1971. The effect of hot-cutting, size, and aging on tenderness of broilers. Poultry Sci., 50:1648.

Yates, J. D., and C. C. Brunson. 1971. Quality of cage reared broilers. Poultry Sci., 50:1648.

Yeates, T. M. 1960. Some problems concerning the mechanism of light action in poultry. World's Poultry Sci. J., 10:324-326.

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