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EFFECTS OF CAGE VERSUS FLOOR REARING AND DIFFERENT DIETARY PROTEIN LEVELS ON PERFORMANCE AND CARCASS QUALITY OF CORNISH GAME HENS AND BROILERS

By

Pronoti Robinson

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ABSTRACT

EFFECTS OF CAGE VERSUS FLOOR REARING AND DIFFERENT DIETARY PROTEIN LEVELS ON PERFORMANCE AND CARCASS QUALITY OF CORNISH GAME HENS AND BROILERS

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Four dietary protein levels (20%, 22%, 24% and 26%) were fed to cornish game hens (CGHs) and broilers raised on litter floor and in cages for 4 and 6 weeks, respectively. They were started at one-day of age on the experiment. Combined data from CGHs and broilers showed significant effects of protein ($P<.001$) and rearing ($P<.0001$) on feed efficiency, but not on live weight or feed consumption. Ration with 20% protein yielded highest percentage of Grade A carcasses in CGHs ($P<.005$). Rearing chickens on floor produced better carcass quality compared to cage system ($P<.05$). No significant correlations were detected between breast blisters or percent abdominal fat with live weight. Highest eviscerated weights obtained were 66.63% and 72.51% of live weight for CGHs and broilers, respectively. Cervical dislocation method of slaughter yielded a higher percentage of Grade A carcasses than did conventional method, but statistical analysis eliminated the influence of slaughter methods on carcass appearance ($P<.05$).

To my parents and beloved husband, without whom and without whose prayers I could never have come this far, I sincerely dedicate this work

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CHAPTER 1

INTRODUCTION

The country where the author comes from and where she plans to return to serve her people, is Bangladesh. It is socio-economically one of the most underprivileged nations of the world. There are 110 million people crowded in a land, the size of which is about that of state of Wisconsin. Within a period of only a few years war, flood, famine, and deadly diseases, each in turn plunged a once pleasant and prosperous country to a land of poverty and starvation. With the beginning of a new day, thousands of new lives are born in this land without having any hope and little food, education, health care, a roof overhead, or even a job assurance for the future. Nutrition, for many, is inadequate to improve the quality of life, and in most cases, is barely adequate to support life.

In spite of many limitations, the Government of Bangladesh and other non-governmental organizations are making efforts to improve the nation's economic conditions. There are areas where potential developments can be made--poultry production is such an area.

1.1 Need for the Study

Bangladesh has a very old history of domestic poultry rearing. Almost every village in Bangladesh has poultry that contribute a nominal portion of the income for rural households. According to an estimate by Okada *et al.* (1988), there are about 60 to 70 million chickens in Bangladesh. Between 1960 and 1970, the poultry population had fluctuated about 19 million to 20 million. The cyclonic storm in 1970 and the war of independence in 1971 destroyed a substantial number of livestock including more than 1 million chickens (Nyrop *et al.*, 1975).

The chickens in Bangladesh consist mostly of a nondescript indigenous type called 'Deshi' chickens (Okada *et al.*, 1988). These birds are medium in size (1.0 to 1.4 kg.), produce few and small sized eggs, and are raised for both eggs and meat. All of the operations related to their raising are conducted on a small scale with traditional village practices. They are generally raised by the 'free method' (Obaidullah, 1969). They roam freely like scavengers and collect food from backyards, gardens, and fields. The chickens sustain themselves on household scraps, grain left over in the fields and gardens, vegetables, insects, etc. Occasionally they are given small quantities of broken rice or rice husks.

Although there is a tremendous need to improve poultry production in Bangladesh, no attention or research was accomplished in this discipline. No significant work is being done to utilize chickens for providing food or for economic improvements among the poor rural farmers and their families. The main hindrance is that Bangladesh like other less developed countries has a small number of technically trained people and a shortage of support services to accomplish such an undertaking. Today Bangladesh needs well trained personnel with expertise to promote modern scientific ideas and technology in order to improve the production of farm animals. There is a great need for adequately trained people to organize, modernize, and manage poultry farms in Bangladesh. Lack of technical knowledge in this vital aspect of national development has resulted in a significant loss of economic growth. This author desires to take back home with her adequate and effective training, to improve the nutrition of her people. Bourne (1980) justifies this need in the following words:

> "It is desirable that the thesis research problem of the graduate student be on a topic that is appropriate for their work when they return to their home country. Many students return to their countries with an advanced degree unable to relate to the research needs and possibilities in their own country. If their thesis research relates somehow to the needs of their country, they have at least a start on the right track" (p. 52).

1.2 Goals and Objectives of the Study

In the past, in developing poultry rations, main emphasis was given to formulate feeds which would produce a maximum biological efficiency, that is, highest live weight gain and best feed conversion. However, the concept that 'better the feed conversion, the more efficient the producer' is not always true. The main goal for a poultry meat producer is to achieve maximum profit. The highest live weight gain and better feed efficiency does not always give the highest profit (Wegner, 1977). This is because, the main factors that determine production costs of poultry are growth rate and feed costs per unit of growth (Leenstra, 1989). Since feed cost represents 70% of the total cost of production (Charles, 1980) and protein is one of the most expensive item in the cost of a complete feed, every effort should be made to reduce its use without lowering the performance of chickens at the same time. For a country like Bangladesh with minimal cereal grain resources and low availability of protein, it was deemed necessary to identify *minimum* protein level that would satisfy the nutritional requirements of the chickens, and at the same time produce optimum performance. Also, from the standpoint that many farmers in Bangladesh do not have enough land to establish and maintain even small backyard poultry operations, the practicality of using cages as an effective housing method for raising poultry to a certain age needed to be evaluated.

Again it is becoming increasingly important to consider not only weight gain, feed conversion, feed costs or combinations of these factors, but also the carcass quality of meat animals. In recent years there has been an increased concern over excessive fat deposition in chickens. Abdominal fat adds little to overall carcass quality and in some cases are considered as waste. High amounts of abdominal fat can reduce processing yields since it is often removed from the carcass together with the intestines during processing.

The relationship between eviscerated carcass weight and live body weight is an important measure of efficiency in poultry processing (Jaap *et al.*, 1950), and it appears that much more research is needed to identify the various factors affecting meat yield of poultry.

Again, in a country like Bangladesh where most villages have no electricity, the feasibility of applying electrical stunning prior to conventional slaughter may be impractical. In that case the feasibility of incorporating a new slaughter method such as cervical dislocation, and its effect on bleeding and carcass appearance needed evaluation.

Considering these goals, the primary objectives of this research were designed to study

1) the effects of different dietary protein levels and rearing methods (eg., cage and floor housing) on the performances of cornish game hens* and broilers. Factors to be evaluated are a) body weight, b) feed consumption, c) feed efficiency, d) breast blisters and e) carcass grading;

2) the influence of slaughter method (conventional *vs* cervical dislocation) on carcass appearance;

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*A cornish game hen is a young immature chicken weighing not more than 2 lb (0.9 kg) dressed, which means the live market weight should be between 2.25 and 2.50 lb (1.02 and 1.14 kg). Normally, it takes from 4 weeks and 4 days to 5 weeks of growing time for bird to reach the desired weight and is prepared from a Cornish chicken or the progeny of a Cornish chicken crossed with another breed of chicken.

3) the correlations between live weight and incidence of breast blisters, percent abdominal fat and eviscerated weights.

1.3 Organization of the Study

Including the introductory section, this thesis is divided into five chapters. Chapter 2 is concerned with the review of literature pertinent to the present study.

The experimental design, diets, general description of the experimental methods, and means for statistically analyzing the data are outlined in Chapter 3.

Chapter 4 discusses the principal findings regarding the effects of different dietary protein levels on cornish game hens and broilers, comparison between cage and floor housing systems, and also the influence of slaughtering methods on carcass appearance.

The last chapter summarizes the findings and provides the conclusions.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

The review of literature pertinent to the topic under investigation is divided into six sections. The first section is the protein requirements of broiler chicks. The second section covers the cage *vs.* floor rearing of broilers. The third topic is the abdominal fat in poultry. The fourth section deals with the breast blistering in broilers. The fifth area is the processing of broilers, and the last section focuses on the meat yield of poultry.

2.2 Protein Requirements of Broiler Chicks

Poultry derive their protein requirements from cereals as well as from the protein-rich foods (Feltwell and Fox, 1978). The dietary protein requirement is actually the requirement for amino acids contained in the protein. Although some amino acids can be produced within the body of the bird by the transformation of other amino acids, some of the amino acids are essential in the sense that these have to be provided by the dietary protein or as dietary supplements since the bird cannot synthesize these. Therefore, the protein requirements have two parts, (i) the essential amino acids needed by the bird because it cannot synthesize these, and (ii) sufficient protein to supply either the nonessential amino acids themselves or to supply amino nitrogen for their synthesis.

Various workers have studied the quantitative relationship between available calories in poultry rations and their protein content. Subhaschandran and Balloun (1969) reported that the protein requirements of poultry increase as the energy content of the diet increases, and these requirements, therefore, can no longer be expressed as percentage of diet but rather should be expressed as energy to protein ratio. The concept of the energy:protein ratio was developed as a simple means to balance the protein and energy contents of broiler and hen diets (Combs and Romoser, 1955). The latter workers observed that chicks fed on high energy diets needed higher dietary protein contents than those fed on low energy diets for maximum growth.

Hill and Dansky (1950) found that growth was reduced when a high energy and low protein ration was fed, but that growth was restored when the energy level was lowered. Sunde (1956) showed that a ration high in protein and low in energy caused a reduction in the growth rate and a reduced efficiency of feed utilization. Raising the energy level of this ration by the addition of fat improved both growth and feed efficiency. It can therefore be concluded from these studies that when the percent protein in the diet is high, the energy level must be high. When the protein level is lower, the energy level can be lower.

Donaldson *et al.* (1956) demonstrated improvements in growth and food utilization of chicks as a result of increasing dietary protein content. Nakamura *et al.* (1988) used three energy levels, 2900, 3100 and 3300 kcal. metabolizable energy (ME)/kg., and three protein levels of 16%, 19% and 22% to formulate nine grower-finisher rations fed to broilers. They found that when protein level was high, weight gain and feed efficiency progressed. Gowda (1973) examined the performance of broiler chicks at four levels of protein (15%, 18%, 21% and 24%) from 1-7 weeks. All diets were isocaloric having 3000 kcal. ME/kg. In their study, 24% dietary protein gave maximum weight gain. Efficiency of feed utilization was also improved by increasing protein level of diet. Similar observations, that, broiler growth increases with increasing dietary protein content were also made by Matterson *et al.* (1955), Leong *et al.* (1959) and Pesti and Fletcher (1983). By reviewing these literature one can conclude that growth and feed efficiency of broilers improve with increasing dietary protein content. These findings, however, are contradictory with the result reported by Summers and Leeson (1985). Feeding a range of dietary crude protein levels (16% to 22%) during the 28 to 49-day period, these workers found that crude protein level had little influence on male broiler body weight gain and feed conversion. The chicks offered 18% crude protein diet gained significantly more weight during this period than those receiving a 22% crude protein diet.

Subhaschandran and Balloun (1969) reported that protein requirements of chickens are highest after hatching and begin decreasing after 6 to 8 weeks. Twining *et al.* (1974) reported that broiler chicks receiving a low protein starter had a lower body weight and feed conversion at 4 weeks of age as compared to those receiving the required level. Levels of dietary protein used in rations fed to growing broilers are extremely variable. Singh (1972) recorded better growth and feed efficiency in broiler chickens with a protein level of 24% having a C/P ratio of 125:1. Sunde and Bird (1959) found that the protein requirement of chickens fed a ration containing 1760 kcal. productive energy/kg. was 20% to 21% from 0 to 6 weeks of age. Singh *et al.* (1978) reported that highest body weight of broiler chicks was obtained with mash containing 24.6% crude protein and 2745 kcal. of metabolizable energy, whereas the lowest body weight was obtained with mash having 29.1% percent protein and 3166 kcal. metabolizable energy. These results are in close agreement with the findings of Lewis and Morgan (1963) who found the protein and energy levels of 24.9% and 2700 to 2900 kcal ME/kg. to be optimum for growth of broiler chicks.

Prasad *et al.* (1973) conducted a 2x4 factorial experiment with one-week old commercial crossbred broiler chicks using diets containing two protein levels (19.9% and 23.2%) and four calorie (ME): protein rations (143, 153, 134 and 122). As both protein and energy levels were increased, corresponding improvements in weight gain and feed efficiency were observed. The favorable responses in weight gain and feed efficiency were significant ($P<0.05$) when metabolizable energy (ME) was increased from 2834 to 3044 kcal/kg. at 19.9% protein but not at 23.2% protein. Panda and Reddy (1976) reported that starting broiler chicks require about 23%-24% protein with an energy content of about 3100 kcal. ME/kg. diet.

From the results of these studies one can conclude that protein requirements of broiler chicks during the starting phase for optimum performance is above 20%, and probably around 24% with an energy concentration of 2700 to 3100 kcal. ME/kg. diet.

Nagabhushanam *et al*. (1979) tested four protein levels (18%, 20%, 22% and 24%), each having four dietary energy levels (2520, 2430, 2340 and 2250 kcal. ME/kg.) in commercial starter chicks. Based on their findings, the authors reported that during summer, calorie:protein ratios ranging from 2250:24 to 2520:24 gave maximum weight gains and feed efficiency while during winter, calorie: protein ratios ranging from 2250:22 to 2430:22 gave adequate body weight gains and feed efficiency. The protein utilization was maximum on 18% and 22% levels during summer and winter respectively. Cilly *et al*. (1973) studied the effect of season (summer and winter) on protein and energy requirements of White Leghorn chicks. Four protein levels 17%, 19%, 22%

and 25% were fed each at three levels of energy, i.e. 2400, 2700 and 3000 kcal. ME/kg. It is apparent from their data that the performance of the chicks was better with 22% protein at an energy concentration of 2400 and 2700 kcal. ME/kg. in summer: The same energy concentration was satisfactory in winter also but at a higher level of protein, i.e. 25%.

These data indicate that the protein and energy requirements of broiler chicks are different during summer and winter months.

2.3 Cage vs. Floor Rearing of Broilers

A large amount of investigational work has been done on broilers in cages. Body weight, mortality, breast blisters, carcass quality and feed conversion comparisons have been made with birds grown on litter. Andrews *et al.* (1975) found no significant difference ($P<0.05$) between cage- and floor-reared broilers. Their 8-week body weights were 1513 and 1485 grams per broiler, respectively. Breast blisters were found on only 1.5% of the caged broilers. The floor-reared broilers were checked for breast blisters, enlarged feather follicles and leg problems; but the incidences were negligible. Significant differences in body weight were noted between birds of different tiers in cages. The broilers, at 8 weeks of age in tiers 2 and 3 were heavier ($P<0.01$) than those in the bottom or top tiers. These authors concluded that with the technology available at that time, small broilers could be grown successfully in cages as Rock Cornish Game Hens with certain limitations. With proper cage floor breast blisters could be eliminated.

Welch *et al.* (1970) found that body weights of both males and females grown to 56 days of age in cages were lower than the body weights of birds reared on floor with litter. Breast blisters were present in 83% of cage-grown birds examined.

Andrews and Goodwin (1973) observed no statistically significant differences for 8-week live body weights among the floor- and cage-reared broilers. At 9 weeks of age, birds on the second and third tier of cages were significantly heavier ($P<0.05$) in live weight than the birds in the other tiers, or on the floor. No significant difference was found among the cage- and floor-reared broilers for feed efficiency.

It is therefore apparent from the reports of these workers that when feed efficiency and broiler live weight are considered, there is no significant difference between cage and floor housing methods. Breast blisters are said to exist only in cage-grown birds, which however can be eliminated with proper flooring material.

2.4 Abdominal Fat in Poultry

Fat is considered as an important factor which influences the quality of a poultry carcass. In recent years there has been an increased concern over excessive fat deposition in broilers. The main fat depots are located beneath the skin, in the abdominal cavity, and especially around the viscera. Although skin fat, including the depot areas on the breast and back, are essential for acceptable human consumption qualities, visceral and abdominal fat add little to overall carcass quality and are considered as waste product. Kubena *et al.* (1974) pointed out that

> "Deposits of fat in the abdominal area of the broiler are considered a waste product in the poultry industry since some of the fat is freed from the carcass during processing. Not only is the abdominal fat a loss, but it represents an added expense since pollution control requires that the added fat be removed from processing plant water. Some of the fat adheres to portions of the digestive system and is reprocessed as a component of poultry-by-product meal. The loss in this case is the difference in the cost of production of this fat and its value as a component of the poultry-by-product meal. Some of the fat adheres to the carcass of the processed broiler. In further processing such as frying, it would appear that the larger the quantity of fat, the greater the cooking loss" (p. 211).

Fat deposition can be influenced by environmental factors and to a larger extent by nutritional and genetic factors. Among environmental factors influencing fat deposition are housing systems: broilers grown in cages have a higher fat content than broilers reared on litter (Deaton *et al.*, 1974); and temperature: moderately high temperatures give fatter broilers compared to low temperatures (Kubena *et al.*, 1974). Goodwin (1980) reported that the amount of abdominal fat which comprises from 2% to 4% of total body weight in today's broilers is influenced by several factors such as genetics, nutrition and sex. Differences among commercial broiler strains in abdominal and carcass fat provide partial evidence that these morphological traits are influenced by heredity. Middelkoop *et al.* (1977) tested two commercial parent lines and six commercial crosses. They found considerable differences in abdominal fat, between the two sexes and among the stocks from different breeders, but not between strains from the same breeder.

A review of the literature by Kubena *et al.* (1974) reported that the dietary energy level of the starter diet influences the quantity of abdominal fat in both sexes i.e., as dietary energy level increases, the quantity of abdominal fat in broilers increases. Also, within each dietary treatment, the abdominal fat in females was of a higher percentage of body weight than in the males. Essary *et al.* (1960) reported that when birds acquire energy in excess of their normal metabolic needs, fat deposition occurs. A considerable portion of this fat is deposited in the abdominal area.

Experiments conducted by Deaton *et al.* (1981) showed that as the dietary fat level increased, the amount of abdominal fat in broilers increased under both a moderate and a high temperature rearing regimen. Griffiths *et al.* (1977), however, did not observe an increase in abdominal fat as dietary fat level increased. Thus, this relationship between the dietary fat level and abdominal fat deposition in broilers remains inconclusive.

Summers and Leeson (1979) indicated that energy intake, rather than dietary energy level, is the main factor which influences abdominal fat deposition. Diets of equal energy content but different in amount of protein resulted in marked differences in abdominal fat, pointing out that carcass fat content can be reduced by dietary means; however, the cost of higher dietary protein levels can be uneconomical.

The estimation of fat in chickens usually involves laborious and time consuming procedures. Becker *et al.* (1979) reviewed several methods of fat estimation that have been designed to lower cost and time involved in estimation of fat in broiler chickens and identified abdominal fat weight as an excellent predictor of total, carcass, and intestinal fat. These authors justified their results in the following words

> "The correlation coefficients and the squares of the coefficient, r^2 (which gives the proportion of the variance of a trait attributable to the relationship with another trait) between the two traits and the various measures of fat in the chicken shows that the abdominal fat or percent abdominal fat had a higher correlation in every comparison, both male and female. Even when abdominal fat weight was eliminated from total fat to avoid a part-whole relationship the comparison favored the use of abdominal fat *vs.* percent backskin fat. It took 8 min. to dissect, weigh, and record abdominal fat; the backskin procedure required about 7 to 8 days....On the basis of statistical considerations, time and cost abdominal fat was superior to measuring backskin fat for predicting total, carcass, and intestinal fat" (p. 840).

Sonaiya (1985) reported abdominal fat weight as the best predictor of total body fat weight. Whenever difficulty of operation and time are constraints to fat estimation, the measurement of abdominal fat thickness is highly recommended in predicting total body fat content.

From the findings of these experiments it can be concluded that abdominal fat constitutes about 2% to 4% of total body weight and is the best predictor of total body fat weight. It is influenced by a number of factors such as housing, temperature, heredity, nutrition, sex, dietary energy level and energy intake.

2.5 Breast Blistering in Broilers

Considerable research has been done to overcome the occurrence of breast blisters in broilers. Breast blisters are said to be influenced by a number of factors: (1) an abrasive action of litter on the breast while the bird is resting, (2) an irritation of the breast by manure and litter, (3) a combination of (1) and (2). Heavy broilers are usually older and are exposed to the abrasive action or irritation of the litter for a longer period of time and therefore there is a tendency for heavier birds to have more breast blisters and bruises (Smith, 1956).

Breast blisters are said not to exist in birds reared on metal floors normally used for pullet rearing (Brown, 1969). His data suggested an average target weight of 1.64 kg. per bird as being the most suitable for cage rearing, without giving rise to breast blister formation. Lloyd (1969) showed that broilers weighing 1.70 kg. and 1.81 kg.

reared on wire resulted in downgrading of 21.7% and 27.3% respectively due to breast blisters. Proudfoot *et al.* (1979) reported that the percentage of birds graded down because of breast blisters increased linearly as stocking density increased. This trend was significant at the 5% level of probability for females, and approached significance at the 5% level for males.

Experiments conducted by Welch *et al.* (1970) confirmed that breast blistering is significantly correlated with bodyweight and that blister score can be predicted for cages with metal floors. They found the incidence of breast blisters to be 68% to 91%, 55% to 82%, 60% to 67% and 2% to 10% on broilers reared on wire floors, wood slats, plastic mesh and litter, respectively.

Andrews (1972) performed experiments with broilers to ascertain the feasibility of growing broilers in cages. He found that broilers reared in cages with rubber covered nylon floors (RCN) had no blisters when compared with plastic mesh. Andrews and Goodwin (1973) observed similar results of practically no blisters in 8-week old birds grown in cages on RCN floor compared with birds reared on plastic mesh.

It can be summarized from the results of all these experiments that broilers could be grown to heavy weights in cages, under crowded conditions without an incidence of breast blisters and without any detrimental effect to body weight when RCN is used as a flooring material.

2.6 Processing of Broilers

Broiler processing is a system of complex steps to convert the live bird into a ready-to-cook product either as a whole bird or cut up into component parts. Preparing poultry in a ready-to-cook form involves live bird catching, cooping and hauling, holding live birds on a truck, unloading, hanging on the conveyor, stunning, slaughtering, defeathering, eviscerating, inspecting, chilling, grading, packing and finally shipping.

The marketing of ready-to-cook poultry became significant during the 1930's, and rapid expansion began during the 1940's. Today, ready-to-cook poultry is available throughout the country because of the advancements in the highly commercialized operation of killing, dressing, eviscerating, grading, packaging and rapid transportation of the meat to distant markets (Taylor and Helbacka, 1968a).

A major concern during assembly of poultry is the minimizing of bruises on the carcass. Field studies revealed that considerable bruising occurs in the poultry house before the catching crews arrive (Cox, 1981). Hewell (1986) reported that up to 50% of downgrading bruises can occur in the broiler house prior to catching operations. Hamdy *et al.* (1961) reported that 90% of all bruises were less than 12 hours old. Goodwin (1986) stated that most bruises occur within 12 to 24 hours prior to processing. Some of the reasons listed by Goodwin (1986) are house construction, equipment placing and management factors such as not allowing feeders to run empty during the final 24 hours, or failing to have the house ready when the catching crews arrive. Childs *et al.* (1969) reported that 58.4% of bruises on the breast and legs, of severity sufficient to require downgrading because of trimming, occurred prior to catching operations. Taylor and Helbacka (1968b) found significant differences among catching crews as to the numbers of bruised birds. In their studies of over 6000 flocks, percentages of bruised birds varied by monthly averages from 16.6% to 28.4% over a two year time span. These authors also reported about 1% fewer bruises on birds loaded in the dark as compared to daylight loading.

It is therefore apparent from these reports that bruising is usually attributable to house construction, equipment placing, rough handling of birds during catching, cooping, loading, unloading, time of the day and number of catching crews.

Brant *et al.* (1982) reported that withdrawal time for feed and water is about 10 hours. Live bird shrinkage can range from 0.3% to 0.5% per hour for the first 12 hours off feed and will average approximately 0.2% per hour over a 24-hour period. Furthermore, the incidence of fecal contamination can be kept to a minimum when the total feed and water withdrawal time is from 8 to 12 hours. Wabeck (1972) reported a linear relationship between percentage shrinkage and the time off feed. Sathe and Khan (1970) observed that the birds held in crates without food and water lost 10% of live weight in 20 hours and the dressing yield from those birds was significantly lower after 12 hours fasting. Sahoo et al. (1974) reported that broilers held in a cool and well ventilated place without food, bedding and litters, even though plenty of drinking water was allowed, lost 4.91% to 6.66% of live weight at 16 to 18 hours fasting. The dressing yield in these fasting birds was 0.94% to 2.82% lower than the birds which were slaughtered without fasting.

From these studies it can be concluded that prior to killing, birds should be allowed sufficient time to clear the digestive tract without extending the time to the point that would reduce the yield of salable product.

Stunning is required for all animals prior to slaughter by U.S. law. The method of choice in the poultry industry is electric shock. Stunning is essential for satisfactory bleeding and feather release (Brant *et al.*,1982). The total and relative amount of blood loss through bleeding has always been of interest with respect to the appearance of the dressed poultry as well as from the economic standpoint (Newell and Shaffner, 1950). Blood loss must be maximum at the time of slaughter, and is a desirable characteristic of any animal slaughtered for human consumption. Kotula and Helbacka (1966b) reported that salable parts of chickens contained 36.7% to 45% of the total blood of the live bird. Carcass appearance grade may be lowered when veins containing excessive amounts of blood are ruptured, thus giving the appearance of a bruised carcass. This author has not found any improvement on these figures in recent years.

Newell and Shaffner (1950) endeavored to increase the blood loss of New Hampshire chickens by subjecting these to three slaughter methods: (1) Kosher slaughter, (2) debraining by inserting a knife through the mouth, and (3) beheading. Kosher slaughtered birds lost the greatest amount of blood, followed by those that were debrained, and then by those that were beheaded. Davis and Cole (1954) used five slaughter methods in a bleed out study with Leghorn broilers: (1) single carotid artery and jugular vein cutting, (2) both carotid arteries and jugular vein cutting without severing the wind pipe, (3) beheading, (4) debraining with both carotid arteries and jugular vein cutting, and (5) stunning by striking the head with a stick and then both carotid and jugular vein cutting. Kotula and Helbacka (1966a) made an effort to study the variation in blood loss over the different time intervals in commercial broilers. The slaughter methods used to kill these birds were: (1) electrical stunning and standard cutting, (2) debraining followed by standard cutting, (3) captive bolt stunning followed by a standard cutting, (4) carbon dioxide immobilization followed by a standard cutting, (5) severing of both jugular veins and carotid arteries, and (6) slaughter by a standard cutting. These workers found that the greatest bleed out came from birds which had been mechanically stunned before slaughter, whereas in Davis and Cole's (1954) experiment mechanically stunned birds gave the second poorest bleed out of the five methods used.

Apparently, the results of these studies indicate that some slaughter methods are experimentally more effective than others under certain circumstances, however, these may not always produce the greatest bleed out. Therefore, the superiority of any one method and its exclusive use in the processing plants may be questionable.

In reviewing the research results on poultry slaughter methods, Heath (1984) states

> "Some of the research results from which poultry slaughter methods were developed were wrong. Because of this, only about one third of broiler chickens are stunned in stunners as they are used today; the others are either killed outright or not stunned sufficiently. Although dead birds bleed slightly more slowly than stunned birds during the first 90 seconds after venesection, there is no difference between blood losses of the two groups after 180 seconds. Different amounts of blood left in the carcass make no detectable difference to the carcasses, and the amount of blood left in the carcass does not affect the keeping quality. It is suggested that this lack of correlation between blood draining from the carcass and the quality of the carcass may be because the capillary bed of the muscles does not lose any blood--all the blood coming from the neck may be from viscera and large blood vessels. These findings indicate that all birds should be killed in the stunner, thus preventing the cruelty which is associated with present methods of slaughter" (pp.157-158).

The U.S. Standards of quality and grades for poultry are used extensively for grading purposes. The basic reason for grading is to classify the products according to economic value. The factors affecting product grade include body conformation, fleshing, fat cover, deformities, flesh and skin bruises and such dressing defects as pinfeathers, disjointed or broken bones, missing parts, discolorations, poor bleeding, tears, cuts and abrasions (Brant *et al.*, 1982).

2.7 Meat Yield of Poultry

The percentage of dressed carcass weight to live body weight is often used as a measurement of meat production in farm animals. Although eviscerated poultry carcasses are not completely comparable with the dressed carcasses of other kinds of livestock, a study of the relationship between eviscerated and other bodyweights can be of aid in the estimation of meat production in poultry (McNally and Spicknall, 1949). Many workers have reported data dealing with dressed and eviscerated yields of broilers. In these reports by Lowe (1941); Jull *et al.* (1943); Essary *et al.* (1951); and Jaap *et al.* (1950), the dressed yields varied from 85% to 90% of live weight and eviscerated yields varied from 65% to 75% of live weight.

Several reports are available regarding the various factors affecting meat yield of poultry. The meat yields from live, dressed, and eviscerated Rhode Island Red cockerels were reported by McNally and Spicknall (1949). They slaughtered 183 birds at varying ages (25 biweekly intervals) with liveweights varying from 600 to 2700 grams. In their data covering this wide range of age and size, it was observed that the percentage dressed and eviscerated yields, as well as edible flesh, became greater as live body weight increased. The relationship was linear and was accurately predictable from regression formulae.

Studies were also conducted by several workers to determine the effects of strains and crosses on yields of eviscerated (ready-to-cook) poultry. Renard (1949) noted considerable variation among breeds and crosses with regard to loss during dressing both from live to New York dressed and from live to eviscerated weights. Hathaway *et al.* (1953) found no significant difference between strains as to percentage loss from live to New York dressed weights. However, they did find a difference between strains with the Dark Cornish yielding the highest percentage of total edible meat based on both live and on eviscerated weights. Frischknecht and Jull (1946) observed the same results in their studies with 12 week old chickens. In all trials, the Dark Cornish, yielded the highest percentage of total edible meat and breast meat on the basis of live weight and also eviscerated weight.

Orr (1955) reported no significant effect of strains, sex and diet on chilled dressed weight as a percentage of live weight. However, on the basis of ready-to-cook weight as a percentage of live weight, the effect of strain and sex was highly significant with White Cornish giving the highest yield. Reports by Stotts and Darrow (1953) indicated that the introduction of Cornish breeding either in pure form or in crosses resulted in increased yields of edible meat.

Several conclusions about the meat yield can be drawn from these studies. Eviscerated yields vary from 65% to 75% of live weight, and these yields become greater as live body weight increases. Also, the results from these trials indicated that certain strains and crosses differ in the yields of eviscerated weights when expressed as a percentage of live weight. In other words, strains have a significant effect on eviscerated weight as a percentage of live weight. Contradictory results, however, are reported regarding the effects of strains on the yields of dressed weight. Hathway *et al.* (1953) and Orr (1955) observed no significant difference between strains, but Renard (1949) reported a significant variation among strains with New York dressed weights when expressed as a percentage of live weight.

CHAPTER 3

METHODOLOGY

3.1 Experimental Design

To determine the effects of different dietary protein levels and rearing methods on the performances of cornish game hens and broilers, a 4 x 2 factorial arrangement of treatments were involved with four levels of dietary protein (20%, 22%, 24%, and 26%), and two rearing methods (floor and cage housing). Treatments involved were composed of 8 possible combinations of 2 factors, each combination having 4 replicates (Table 1). The duration of the experiments was six weeks, initiated on April 3, 1990 and terminated on May 15, 1990.

3.2 Experimental Diets

An attempt was made to evaluate further the protein levels required for optimum performance of cornish game hens and broilers. The formula and chemical composition of experimental rearing rations during 0-3 week and 3-6 week periods are offered in Tables 2 and 3, respectively. For the first 3 weeks, all chicks were given diets containing approximately 1.0% of calcium and 0.45% of phosphorus (Table 2). From 4 to 6 weeks of age, the birds were provided with their respective diets containing approximately 0.9% of calcium and 0.4% of phosphorus (Table 3).

Table 1. Experimental design for cornish game hens and broiler chicks

	Floor				Cage			
Period	Protein(%)				Protein(%)			
Cornish game hens (0-4 wks)	20	22	24	26	20	22	24	26
Broilers (0-6 wks)	20	22	24	26	20	22	24	26
No. of replicates	4	4	4	4	4	4	4	4
No.of chicks/replicate	10	10	10	10	10	10	10	10

Table 2. Formula and chemical composition of experimental rearing rations during 0-3 week period

Ingredients	Protein levels			
	20%	22%	24%	26%
	lbs	lbs	lbs	lbs
Corn, yellow	663	596	523	451
Wheat grain	663	589	521	453
Soybean meal (44%)	513	635	756	877
Fishmeal (60.5%)	80	80	80	80
Fat (animal-veg.)	20	40	60	80
Dicalcium phosphate	27	26	25	23
Limestone, ground	22	22	23	24
Salt	5	5	5	5
Methionine	2	2	2	2
Vit.-mineral premix	5	5	5	5
Totals (lbs)	2000	2000	2000	2000
Calculated analysis				
Crude protein (%)	20.01	22.01	24.01	26.00
Crude fat (%)	3.44	4.29	5.14	6.00
Crude fiber (%)	3.42	3.71	3.99	4.27
Calcium (%)	1.01	1.01	1.03	1.05
Avail. phosphorus	0.45	0.45	0.45	0.44
ME* (kcal/kg)	2913	2908	2895	2889
Calorie: protein	145.58	132.14	120.58	111.1

* Metabolizable Energy

Table 3. Formula and chemical composition of experimental rearing rations during 3-6 week period

Ingredients	Protein levels			
	20%	22%	24%	26%
	lbs	lbs	lbs	lbs
Corn, yellow	665	601	526	454
Wheat grain	664	587	522	454
Soybean meal (44%)	513	635	756	877
Fishmeal(60.5%)	80	80	80	80
Fat(animal-veg.)	20	40	60	80
Dicalcium phosphate	21	20	19	19
Limestone, ground	20	20	20	19
Salt	7	7	7	7
Methionine	7	7	7	7
Vit.-mineral premix	3	3	3	3
Totals (lbs)	2000	2000	2000	2000
	Calculated analysis			
Crude protein(%)	20.03	22.02	24.02	26.03
Crude fat (%)	3.44	4.29	5.15	6.00
Crude fiber(%)	3.43	3.71	3.99	4.27
Calcium (%)	0.91	0.91	0.91	0.91
Avail. phosphorus	0.40	0.40	0.40	0.41
ME* (kcal/kg)	2917	2913	2904	2897
Calorie: protein	145.64	132.28	120.90	111.31

* Metabolizable Energy

3.3 Methods of Experiment

A total of 320 one-day old cornish game hen/broiler pullets from a commercial hatchery was used in this experiment. Ten chicks were randomly alloted to each of the 16 floor pens (10 x 7.5 sq. ft.) and 16 cage units (2 x 3 sq. ft., 1.8 ft. high) after recording their average body weights. The cage units comprised two 4-tier cage arrangements with 2 cages per tier. Wood shavings were used as litter for floor pens. Room temperature ranged from 78° F to 80° F. Both feed and water were available *ad libitum* throughout the experimental period. Birds that died in the cage or floor system during the first three days were replaced. After three days mortality was recorded as it occurred. Data on weight gain were recorded at 3, 4, 5 and 6 weeks of age. Feed consumption was recorded over the 0-4 and 0-6 week periods, and feed conversion was calculated as the unit weight of feed per unit body weight.

At 4 and 5 weeks of age, three chicks per replicate were randomly selected for slaughter. At the end of the experiment, remaining broilers from each replicate were slaughtered. The birds chosen for slaughter were leg-banded to permit individual identification at all weighings and upon carcass evaluation after slaughter. Prior to slaughter, the chickens were kept in wooden crates overnight.

On the following morning the chicks were taken out of the crates, and suspended by their hocks from shackles of an overhead conveyor. Approximately half of the birds were stunned by electric shock and killed by conventional method (single carotid artery and jugular vein cutting). The rest of the chickens were not stunned and killed by cervical dislocation method. Care had been exercised to obtain a thorough bleeding before the birds entered the scalding tank. The feathers were removed after semi-scalding (at 125° F, 7 rotations for cornish game hens and 15 rotations for broilers) by the use of a mechanical picker. Defeathered birds were then hung by their feet on the evisceration line from an overhead conveyor, which moved the carcasses through the eviscerating area.

Evisceration was performed as uniformly as possible with several people doing the work. The carcasses were eviscerated by cutting them open down the back on one side of the vertebral column. The neck with skin was cut off at its base and the shanks were removed at the hocks. The respiratory organs, reproductive organs, liver, gizzard, intestines and heart were removed. Care was taken to retain abdominal fat during removal of these organs for further determination of abdominal fat-weight.

As soon as the birds were eviscerated, they were plunged into cold water directly from the eviscerating line for chilling and left there for two or three hours. After chilling, the carcasses were hung on the drip line to permit the carcasses to drain adequately before they were graded and weighed.

The eviscerated carcass weights (giblets not included) were then recorded. Factors affecting product quality included appearance (skin color with regards to degree of bleeding), body conformation (structure or shape of carcass), fleshing (covering of flesh) and finish (layer of fat in the skin). Each eviscerated carcass was then classified according to USDA standards as A, B and C (Table 4). The data were then used to calculate the percentage of Grade A carcasses originating from each dietary protein level.

Carcasses down-graded because of breast blisters were also listed and these data were used to calculate the incidence of breast blisters. The scoring system used for evaluating breast blistering in cornish game hens and broilers is presented in Table 5. The birds which were graded A were considered to have had very slight blisters or no blisters.

Table 4. Scoring system[a] for grading carcasses in cornish game hens and broilers

Score	Grade
86-100	A
75-85	B
60-74	C

[a,b] The grading of carcasses and evaluation of breast blisters (Tables 4 & 5) were based on the scoring system suggested by Dr. Larry Dawson, Michigan State University, East Lansing, Michigan.

Table 5. Scoring system[b] for evaluating blisters in cornish game hens and broilers

Score	Grade
86-100	A[†]
75-85	B[††]
60-74	C[†††]

[†] No blisters or very slight blisters ; [††] Blisters, moderate; [†††] Blisters, severe

The adipose tissue known as gizzard fat was then removed. This layer of fat surrounded the gizzard and lay between the abdominal muscles and intestines. Another layer of adipose tissue known as leaf fat was also removed. This layer extended within the ischium, and surrounded the bursa of Fabricius and cloaca, where it was attached to the abdominal muscles in the area of the bursa of Fabricius. Both gizzard and leaf fats constituted the abdominal fat and their weights were recorded.

3.4 Analysis of Data

Both descriptive and inferential statistics were employed in the analyses of these data. The descriptive statistics were primarily means, standard deviations, percentages and frequency distribution of performance data.

Correlation analysis, an inferential statistics was performed to measure the strength of the relationship between live body weight and incidence of breast blisters, between live body weight and percent abdominal fat weight, and between live body weight and percent eviscerated weight. Before statistical analyses, percentages were subjected to arcsine transformation. Chi-square distribution was used to test the null hypothesis that the carcass appearance and slaughter methods are independent.

The treatment main effects and their interactions were determined by using the general linear model (GLM) procedure of SAS. The experimental unit used to analyze the data was the pen average for each variable. The following statistical model was used for analysis of variance of average live weight, feed consumption and feed conversion.

$$Y_{ijk} = \mu + P_i + R_j + (PR)_{ij} + E_{ijk}$$

where:

Y_{ijk} = a typical observation;

μ = the overall mean;

P_i = an effect due to protein levels with i = 1, 2, 3, 4;

R_j = an effect due to rearing with j = 1, 2;

PR_{ij} = the interaction between the main effects;

k = 1, 2, 3, 4 pens per treatment; and

E_{ijk} = the residual.

Another statistical model was used in the analysis of carcass grading, which is as follows

$$Y_{ijkl} = \mu + P_i + R_j + A_k + (PR)_{ij} + (PA)_{ik} + (RA)_{jk} + (PRA)_{ijk} + E_{ijkl}$$

where:

Y_{ijkl} = a typical observation;

μ = the overall mean;

P_i = an effect due to protein levels with i = 1, 2, 3, 4;

R_j = an effect due to rearing with j = 1, 2;

A_k = an effect due to age with k = 1, 2, 3;

PR_{ij} = the interaction protein level * rearing;

PA_{ik} = the interaction protein level * age;

RA_{jk} = the interaction rearing * age;

PRA_{ijk} = the interaction protein level * rearing * age;

l = 1, 2, 3, 4 pens per treatment; and

E_{ijkl} = the residual.

All statistical analyses of data were performed using the Statistical Analysis System (SAS Institute Inc., 1988).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Influence of Different Protein Levels on the Performance of Floor- and Cage-Reared Cornish Game Hens and Broilers

4.1.1 Cornish Game Hens:

The averages of the final body weights, feed consumption and feed efficiencies of cage- and floor-housed cornish game hens fed on four different levels of dietary protein from 0-4 weeks of age are summarized in Table 6. No statistically significant differences were observed for 4-week live body weights among the cage- and floor-reared birds, although the body weights of the floor-reared birds averaged 0.1 kg. more than the cage-reared birds. In cage-reared cornish game hens, the groups of birds that were offered the 20%, 24% and 26% dietary protein gained significantly more weight than the group of birds offered the diet containing 22% protein. In floor-reared birds, the differences in body weight were nonsignificant due to variable levels of protein.

During the 0-4 week experimental period, nonsignificant differences were observed for feed consumption among the cage- and floor-reared cornish game hens. In cage rearing system, the groups of cornish game hens that were given a diet with 20% protein consumed significantly more feed than did the birds that were offered the diet containing 22% or 26% protein. The birds which were offered a 24% protein diet also consumed more feed during this period than those receiving a 22% protein diet (P<.05). In floor-reared cornish game hens, the group of birds that was given a diet with 26% protein consumed significantly less feed than those that received 22% or 24% dietary protein.

Table 6. Effects of protein levels on the performance of cage and floor reared cornish game hens

Response criterion	Protein level (%)	Rearing system: Cage	Rearing system: Floor
Live weight, kg	20	0.973^{a}	0.995^{a}
	22	0.817^{b}	1.028^{ab}
	24	0.934^{acd}	1.038^{abc}
	26	0.951^{ad}	1.016^{abc}
	Avg. rearing system	0.919	1.019
Feed consumption per bird, kg	20	1.781^{a}	1.599^{a}
	22	1.408^{bd}	1.618^{ab}
	24	1.815^{ac}	1.654^{abc}
	26	1.521^{cd}	1.549^{ad}
	Avg. rearing system	1.631	1.605
Feed efficiency, feed/gain, kg/kg	20	1.828^{a}	1.618^{a}
	22	1.725^{bc}	1.583^{abd}
	24	1.945^{ac}	1.593^{abc}
	26	1.615^{bd}	1.530^{acd}
	Avg. rearing system	1.778	1.581

Note: Within columns, means with different superscripts are significantly different (P<.05).

Nonsignificant differences were observed for feed efficiency among cage- and floor-reared units. For cage-reared cornish game hens, the best feed/gain relationship was obtained by the group of birds that received a 26% protein diet. Statistically ($P<.05$) this feed efficiency did not differ from the group of birds offered the diet containing 22% protein, but was significantly different than the birds offered 20% or 24% dietary protein. In floor-reared birds, the differences in feed efficiency were nonsignificant due to variable protein levels.

4.1.2 Broilers:

The effects of protein level and cage *vs.* floor rearing on the performance of broilers (0-6 weeks) are summarized in Table 7. At the end of the 6 week experimental period, the average body weight of cage-reared broilers was found to be the same as the floor-reared broilers. When comparisons were made among different dietary treatment, the 22% protein diet produced the lowest average body weight in cage-reared broilers ($P<.05$). In floor-reared broilers, the differences were found to be nonsignificant for 6-week live weights due to variable levels of protein.

Broilers reared on the floor consumed 0.159 kg. more feed per bird than did the comparable broilers in cages, however, nonsignificant differences were observed for feed consumption among the cage- and floor- reared broilers. Cage-housed broilers fed on diet containing 20% protein consumed more feed than those fed on diets with 24% or 26% protein (P<.05). Floor-reared broilers offered a diet containing 26% protein consumed significantly less feed than those receiving 20% or 24% protein diet.

Table 7. Effects of protein levels on the performance of cage and floor reared broilers

		Rearing system	
Response criterion	Protein level (%)	Cage	Floor
Live weight, kg	20	1.767[a]	1.706[a]
	22	1.523[b]	1.676[ab]
	24	1.698[ac]	1.694[abc]
	26	1.715[acd]	1.629[abc]
	Avg. rearing system	1.676	1.676
Feed consumption per bird, kg	20	3.458[a]	3.445[a]
	22	2.785[b]	3.347[abd]
	24	3.327[abc]	3.414[ab]
	26	3.242[cd]	3.241[d]
	Avg. rearing system	3.203	3.362
Feed efficiency feed/gain, kg/kg	20	1.964[a]	2.018[a]
	22	1.963[abd]	2.000[abd]
	24	1.998[abc]	2.017[abc]
	26	1.883[acd]	1.991[d]
	Avg. rearing system	1.952	2.007

Note: Within columns, means with different superscripts are significantly different (P<.05).

No statistically significant differences were observed for feed efficiency among the cage- and floor-reared broilers. Andrews and Goodwin (1973) also reported nonsignificant differences among the cage- and floor-housed broilers for feed efficiency. Floor-housed birds offered a diet with 26% protein were significantly more efficient in the utilization of feed compared to broilers fed diets with 20% or 24% protein. In cage-reared broilers, however, the differences in feed efficiency were nonsignificant among different dietary treatments.

The analyses of variance of average body weight, feed consumption and feed efficiency were performed. The data from both cornish game hen and broiler experiments were pooled for statistical analysis. Table 8 shows the mean squares of analyses of variance of performance data. The present result, in which dietary protein had no significant effects on live weight, are in general agreement with other studies. Summers and Leeson (1985) reported that crude protein level had little influence on male broiler body weight gain during the 28 to 49-day period. Lilburn *et al.* (1987) also recorded nonsignificant differences in body weight that were due to variable levels of protein. In contrast to the result of the present study, Pesti and Fletcher (1983) reported that broiler growth increases with increasing dietary protein content. They also found food consumption to be dependent on dietary protein content.

No significant effects on live weight and feed consumption were noted that were due to rearing (Table 8). This observation supports Andrews and Goodwin (1973) who found no significant differences for 8-week live body weights among the floor and cage units.

Table 8. Analyses of variance of average body weight, feed consumption and feed efficiency

		Mean squares		
Source	DF	Live weight (kg)	Feed consumption (kg)	Feed efficiency
Protein (P)	3	0.140	1.536	0.290*
Rearing (R)	1	0.349	0.083	0.781**
P x R	3	0.183	1.166	0.066
Residual	24	0.057	0.874	0.447

*$P \leq .001$; **$P \leq .0001$.

The analyses of variance showed that protein and rearing effects were highly significant for feed efficiency. In cage-reared cornish game hens and floor-housed broilers, the groups which consumed 20% or 24% protein diet required a greater quantity of feed to achieve the same body weight as the birds that were fed the 26% protein ration (Tables 6 & 7). Support for this observation is given by several workers who demonstrated better feed utilization in chicks with increasing dietary protein content (Donaldson *et al.*, 1956; Eberst *et al.*, 1972; Gowda, 1973; Leong *et al.*, 1959; Pesti and Fletcher, 1983; Prasad *et al.*, 1973; Rao *et al.*, 1973), however, optimal feed efficiency has been obtained with broiler grower diets containing as little as 15.5% crude protein (Lipstein and Bornstein, 1975; Summers and Leeson, 1985). The protein level x rearing interaction was not statistically significant for any of these parameters measured (Table 8).

4.2 Effects of Dietary Protein Levels and Cage Vs. Floor Rearing on Carcass Grading

4.2.1 Cornish Game Hens:

Carcass quality is an important consideration because of the further processing used by the industry. In this study, the primary components which together comprise overall carcass quality (i.e., appearance, conformation, fleshing, finish and blisters) were evaluated. Table IX (see Appendix) lists the percentages of cornish game hen carcasses graded into different grade classes according to the protein level fed and the method of rearing. In cage-reared cornish game hens, the group that were offered a diet containing 20% protein yielded highest percentages of Grade A carcasses than did the comparable groups fed diets with 22%, 24% or 26% protein ($P<.005$).

4.2.2 Broilers:

The results obtained with the study to determine the effects of different protein levels and rearing on carcass grading in cage- and floor-reared broilers at 5 and 6 weeks of age are presented in Tables X & XI (see Appendix). When comparisons were made among different dietary treatments, diet with 26% protein yielded the highest percentages of Grade A carcasses in cage-housed broilers at 6 weeks of age ($P<.025$). However, this percentage yield may be influenced by the small size of the sample (see Table XI). In floor-reared broilers at 6 weeks of age and also in cage-grown broilers at both 5 and 6 weeks of age, nonsignificant differences were observed in Grade A carcasses that were due to different levels of dietary protein.

Tables 9 & 10 present the combined data of carcass grading (pooled from cornish game hens and broiler experiments) by rearing and protein levels, respectively. The mean squares of analyses of variance of these data are shown in Table 11. Level of dietary protein, age, rearing and their interactions were the effects tested. Except for appearance grade, the effects of rearing were found to be highly significant for all other components of grading ($P<.001$). Rearing the chickens on the litter floor produced better quality of carcasses compared to cage system ($P<.05$). Support for this observation is given by Andrews *et al.* (1990) who reported that carcass quality is greatly affected by type of flooring.

There were no significant effects observed on appearance, conformation and fleshing grades, due to age. However, it may be noted from Table 11 that the effect of age on blister grade was highly significant (P<.001) and that on finish grade was significant (P<.05).

Table 9. Percentages of carcasses in each grade, by Rearing methods (combined data)

Rearing	Cage (N=130)			Floor (N=145)		
Carcass quality factors	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
		(%)			(%)	
Appearance	36.15 (47)	56.92 (74)	6.93 (9)	46.21 (67)	42.07 (61)	11.72 (17)
Conformation	27.69 (36)	70.77 (92)	1.54 (2)	84.83 (123)	15.17 (22)	0.00 (0)
Fleshing	36.15 (47)	63.85 (83)	0.00 (0)	80.00 (116)	20.00 (29)	0.00 (0)
Finish	57.69 (75)	42.31 (55)	0.00 (0)	78.62 (114)	21.38 (31)	0.00 (0)
Blisters	56.15 (73)	43.08 (56)	0.77 (1)	99.31 (144)	0.00 (0)	0.69 (1)
Total	42.77 (278)	55.38 (360)	1.85 (12)	77.80 (564)	19.72 (143)	2.48 (18)

Note: Figures in parentheses are base Ns for the adjacent percentages.

Table 10. Percentages of carcasses in each grade, by Protein levels (combined data)

Carcass quality factors	Protein levels (%) 20 (N=72) Grade A	B	C	22 (N=70) Grade A	B	C	24 (N=74) Grade A	B	C	26 (N=59) Grade A	B	C
	(%)			(%)			(%)			(%)		
Appearance	54.2 (39)	38.9 (28)	6.9 (5)	35.7 (25)	58.6 (41)	5.7 (4)	32.4 (24)	54.1 (40)	13.5 (10)	44.1 (26)	44.1 (26)	11.8 (7)
Conformation	59.7 (43)	40.3 (29)	0.0 (0)	61.4 (43)	38.6 (27)	0.0 (0)	51.4 (38)	47.3 (35)	1.3 (1)	59.3 (35)	39.0 (23)	1.7 (1)
Fleshing	66.7 (48)	33.3 (24)	0.0 (0)	58.6 (41)	41.4 (29)	0.0 (0)	56.8 (42)	43.2 (32)	0.0 (0)	54.2 (32)	45.8 (27)	0.0 (0)
Finish	79.2 (57)	20.8 (15)	0.0 (0)	65.7 (46)	34.3 (24)	0.0 (0)	66.2 (49)	33.8 (25)	0.0 (0)	62.7 (37)	37.3 (22)	0.0 (0)
Blisters	70.8 (51)	29.2 (21)	0.0 (0)	81.4 (57)	18.6 (13)	0.0 (0)	79.7 (59)	20.3 (15)	0.0 (0)	84.7 (50)	13.6 (8)	1.7 (1)
Total	66.1 (238)	32.5 (117)	1.4 (5)	60.6 (212)	38.3 (134)	1.1 (4)	57.3 (212)	39.7 (147)	3.0 (11)	61.0 (180)	35.9 (106)	3.1 (9)

Note: Figures in parentheses are base *N*s for the adjacent percentages.

Even though a significant effect on conformation (P<.05) and a highly significant effect on finish (P<.001), appearance and blister grades (P<.01) were found due to different protein levels in diets (Table 11), nonsignificant differences existed in overall percentage yield of Grade A carcasses due to variable levels of protein. The age x protein level interactions were found highly significant for appearance and blisters (P<.01), and significant for finish (P<.05). The protein level x rearing interactions were not significant (P>.05) for any of the quality factor evaluated except for appearance (P<.01). The age x rearing interactions were found to be significant for finish and blisters (P<.05), and highly significant for appearance (P<.01). The second order interactions, age x protein level x rearing were highly significant for appearance (P<.001) and blisters (P<.01), but were significant for conformation and finish grades (P<.05). No other literature were available to the author to support or disagree with the findings of the present study on carcass grading.

Table 11. Analyses of variance of carcass grading in cornish game hens and broilers

		Mean squares				
Source	DF	Appearance	Conformation	Fleshing	Finish	Blisters
Age(A)	2	4.3	54.4	56.3	37.2*	158.5***
Protein(P)	3	231.1**	57.5*	48.6	78.2***	86.4**
Rearing(R)	1	2.7	2378.4***	1225.4***	291.3***	4999.9***
A x P	6	217.4**	34.3	11.3	25.7*	68.3**
P x R	3	296.7**	23.0	11.2	24.9	19.3
A x R	2	412.3**	11.4	27.9	48.9*	91.4*
A x P x R	6	238.9***	43.6*	4.3	24.7*	64.4**
Residual	69	62.2	20.9	22.2	19.5	17.1

*P<.05; **P<.01; ***P<.001.

4.3 Breast Blistering in Cornish Game Hens and Broilers

4.3.1 Cornish Game Hens:

To compare the incidence of breast blisters between cage- and floor-reared cornish game hens, the data from all four dietary treatments under each rearing method were pooled for statistical analysis. The scoring system used for evaluating breast blistering in cornish game hens is presented in Table 5.

The results in Table 12 show that breast blisters were present in 30.23% of the cage birds examined. No incidence of blisters was reported in cornish game hens reared on the floor.

Table 12. Breast blisters incidents in cornish game hens, by Rearing system

Rearing system	Blisters (%)	No Blisters (%)	Total
Cage	(13) 30.23	(30) 69.77	(43) 100.00
Floor	(0) 0.00	(46) 100.00	(46) 100.00
Total	(13) 14.61	(76) 85.39	(89) 100.00

Note: Figures in parentheses are base Ns for the adjacent percentages.

Correlation coefficients between live body weight and breast blisters were determined for each rearing method (Table 13). The values, r= -0.174 and -0.168 for cage- and floor-reared birds, respectively were found to be non-significant (P<.05).

Table 13. Correlation coefficients between live weight and breast blisters in cornish game hens

Rearing system	Correlation coefficient (r)	Significance
Cage	(43)[§] -0.174	NS
Floor	(46) -0.168	NS

NS, non-significant;
§ Figures in parentheses are base Ns for the adjacent correlation coefficients.

4.3.2 Broilers:

The percentages of broilers having breast blisters reared in cages or on floor for 5 and 6 weeks are presented in Table 14. The scoring system used for evaluating blisters in broilers was the same as used for cornish game hens (see Table 5). For each rearing method at each age, the data from all four dietary treatments were pooled for analysis.

At 5 weeks of age, 31.11% of the broilers reared in cages were reported to have breast blisters compared to only 2.50% of the broilers reared on floor. At 6 weeks of age, 71.43% of broilers raised in cages had breast blisters, a value within the percentage range reported by Welch *et al.* (1970). These researchers found breast blisters to be 68% to 91% on broilers reared on wire floors in cages. No blisters were detected on broilers reared on the floor for 6 weeks. These findings support Andrews *et al.* (1990) who reported that litter-grown broilers had few or no breast blisters.

Table 14. Breast blister incidents in broilers, by Age and Rearing

Age (wks)	Rearing system	Blisters (%)	No Blisters (%)	Total
5	Cage	(14) 31.11	(31) 68.89	(45) 100.00
	Floor	(1) 2.50	(39) 97.50	(40) 100.00
6	Cage	(30) 71.43	(12) 28.57	(42) 100.00
	Floor	(0) 0.00	(59) 100.00	(59) 100.00
	Total	(45) 24.19	(141) 75.81	(186) 100.00

Note: Figures in parentheses are base Ns for the adjacent percentages.

Table 15 lists the correlation coefficients between live weight and incidence of breast blisters in broilers by age and rearing method. The only highly significant negative correlation ($P<.01$) was that observed between live weight and breast blister incidence in cage-reared broilers at 5 weeks of age ($r= -0.369$).

The results in Tables 13 & 15 therefore indicate that in this study live weight was not the determining factor influencing the extent of breast blistering in both cornish game hens and broilers. Also correlation coefficients were extremely small and thus, these relationships are likely to be of little practical importance. These observations, however, are not in agreement with other studies reported. Welch *et al.* (1970) found breast blistering to be significantly correlated with body weight. Smith (1956) and Andrews (1972) also observed a tendency for heavier birds to have more blisters.

Table 15. Correlation coefficients between live weight and breast blisters in broilers, by Age and Rearing

Age (wks)	Rearing system	Correlation coefficient (r)	Significance
5	Cage	(45)[§] -0.369	*
	Floor	(40) 0.176	NS
6	Cage	(42) -0.173	NS
	Floor	(59) -0.109	NS

*P<.01; NS, non-significant;
§ Figures in parentheses are base Ns for the adjacent correlation coefficients.

4.4 Correlation between Live Weight and Abdominal Fat (Expressed as a Percentage of Live Weight) in Cornish Game Hens and Broilers

4.4.1 Cornish Game Hens:

The means and standard deviations for percent abdominal fat on a live weight basis are presented in Table 16 by protein level and rearing method. Results show that abdominal fat expressed as a percentage of live weight ranged from 0.82% to 1.40%. Abdominal fat contributed to a maximum of 1.40% to the total live weight in cornish game hens reared in cages and a maximum of 1.29% to the total live weight in birds reared on the floor. Among the cage-reared cornish game hens, highest percentage of abdominal fat was produced by those that were fed diet containing 20% protein. Floor-reared birds fed a diet containing 22% protein gave the highest percentage of abdominal fat. With the exception of floor-reared cornish game hens that were given a diet with 20% protein, percent abdominal fat decreased linearly with increasing dietary protein. These results agree with the previous report which indicated that abdominal fat deposition, as a percentage of whole body weight decreased linearly as dietary crude protein content increased (Fancher and Jensen, 1989). Svensson and Hakansson (1977) also reported that chicks fed low protein diets have a high content of abdominal fat. No significant differences were observed among cage- and floor-reared cornish game hens for percent abdominal fat.

Table 17 presents the correlation coefficients between percent abdominal fat and live weight by protein level and rearing method in cornish game hens. Correlation coefficients between these parameters ranged from r= -0.239 to +0.567, and from r= -0.255 to +0.501 in cage- and floor-reared birds, respectively. Results in Table 17 revealed that the correlation between percent abdominal fat and live weight were very low except for the groups that were reared in cages and offered the diets containing 20% or 24% protein

(P<.10), and also for those floor-reared birds that were given a diet with 22% protein (P<.10). No significant correlations (P<.05) were obtained for percent abdominal fat and live weight in either cage- or floor-reared cornish game hens for any dietary protein levels. This suggests that live weight has little or no relationship with the deposition of abdominal fat at this relatively early age (4 weeks). An alternate explanation could be that sample size was not adequate to demonstrate meaningful correlations between these parameters. Again, factors other than growth rate could be involved with this abdominal fat deposition.

Table 16. Means and standard deviations of abdominal fat* in cornish game hens

Protein level (%)	Cage			Floor		
	N	Mean (%)	SD (±)	N	Mean (%)	SD (±)
20	11	1.40	0.383	12	0.96	0.531
22	8	1.19	0.789	10	1.29	0.409
24	11	1.16	0.392	12	1.20	0.275
26	11	0.82	0.198	12	0.94	0.497
Average		1.14[a]			1.10[a]	

* Arcsine percentage transformation for abdominal fat expressed as a percentage of body weight;

[a] Means with same superscripts are nonsignificant.

Table 17. Correlation between live weight and abdominal fat (expressed as a percentage of live weight) in cornish game hens

Protein level (%)	Rearing system	Correlation coefficient (r)	Significance
20	Cage	(11)[§] 0.567	NS
	Floor	(12) 0.159	NS
22	Cage	(8) 0.261	NS
	Floor	(10) 0.501	NS
24	Cage	(11) 0.531	NS
	Floor	(12) -0.255	NS
26	Cage	(11) -0.239	NS
	Floor	(12) 0.099	NS

NS, non-significant;
[§] Figures in parentheses are base Ns for the adjacent correlation coefficients.

4.4.2 Broilers:

The means and associated standard deviations for abdominal fat on a percent of body weight basis are shown in Table 18 by protein levels, age and rearing method. At both 5 and 6 weeks, nonsignificant differences were observed among cage and floor-housed broilers. Contrary to the result of the present study, Deaton *et al.* (1974) observed larger quantities of abdominal fat in broilers reared in cages when compared to broilers reared on the floor.

When comparisons were made within each rearing method at 5 and 6 weeks, both cage and floor broilers showed inconsistency in the percentages of abdominal fat. For unknown reasons, at 5 week of age the cage-reared broilers consuming 20% and 22% protein diet had a larger percentage of abdominal fat than the 6-week old broilers reared under the same condition. Similarly 5-week old broilers reared on the floor and fed 22% and 26% dietary protein had greater quantities of abdominal fat when expressed as a percentage of live weight than 6-week old broilers. The author has no explanation for the reduction in abdominal fat deposition except to attribute these anomalies to variation in sample size.

Table 18. Means and standard deviations of abdominal fat* in broilers

Protein level (%)	Age (wks)	Cage			Floor		
		N	Mean (%)	SD (±)	N	Mean (%)	SD (±)
20	5	11	1.75	0.356	8	1.45	0.469
22		12	1.59	0.562	11	1.71	0.342
24		12	0.98	0.307	11	0.96	0.362
26		11	1.22	0.368	10	1.07	0.543
Average			1.38[a]			1.30[a]	
20	6	15	1.46	0.529	15	1.56	0.554
22		12	1.36	0.483	16	1.50	0.503
24		13	1.53	0.470	15	1.46	0.608
26		2	1.75	0.051	13	0.90	0.459
Average			1.52[a]			1.36[a]	

* Arcsine percentage transformation for abdominal fat expressed as a percentage of body weight;
[a] Within age, means with same superscripts are nonsignificant.

The correlation coefficients between percent abdominal fat and live weight are presented by protein level and rearing method in Table 19. The highest correlation coefficients obtained were r= +0.514 for cage-housed broilers and r= +0.795 for broilers raised on the floor. Except for the group of 6-week old broilers that were reared on the floor and fed the 22% protein diet ($P \leq .0002$), the relationship of percent abdominal fat with 5- and 6-week body weight was low and nonsignificant in both cage- and floor-reared broilers for all dietary protein levels. Failure to show meaningful correlations between percent abdominal fat and live weight suggests that body weight has little or no effect on abdominal fat development. This finding agrees with the report of Middelkoop *et al.* (1976). These workers used 45-day old hybrid broilers and found that the variation in growth rate had no relationship with the percentage of abdominal fat. Factors other than live weight may be involved with this fat deposition. Summers and Leeson (1979) indicated that energy intake is the main factor that influences abdominal fat deposition. In addition, environmental factors such as the season of the year and the temperature may exert some influence on feed intake and subsequent fat deposition in broilers (Kubena *et al.*, 1972). Contrary to the result of the present study, Sonaiya and Benyi (1983) found a highly significant ($P<.01$) correlation between live weight and percent abdominal fat in broilers, but their studies dealt with later stages of growth (>6 weeks).

Table 19. Correlation between live weight and abdominal fat (expressed as a percentage of live weight) in broilers

		Cage		Floor	
Protein level (%)	Age (wks)	Correlation coefficient (r)	Significance	Correlation coefficient (r)	Significance
20	5	(11)§ -0.123	NS	(8) 0.088	NS
22		(12) 0.455	NS	(11) -0.008	NS
24		(12) -0.001	NS	(11) -0.224	NS
26		(11) 0.440	NS	(10) 0.043	NS
20	6	(15) -0.466	NS	(15) -0.031	NS
22		(12) 0.150	NS	(16) 0.795	*
24		(13) 0.514	NS	(15) -0.127	NS
26		(2) -1.000	-	(13) -0.036	NS

NS, non-significant; *$P \leq .0002$;
§ Figures in parentheses are base <u>N</u>s for the adjacent correlation coefficients.

4.5 Correlation between Live Weight and Eviscerated Weight (Expressed as a Percentage of Live Weight) in Cornish Game Hens and Broilers

4.5.1 Cornish Game Hens:

The means and standard deviations for eviscerated weight expressed as a percent of live weight are given in Table 20 by protein level and rearing method. The highest eviscerated weight of the birds obtained was 66.63% of live weight. No statistically significant differences were observed for percent eviscerated weight among cage- and floor-reared cornish game hens, although the eviscerated weights of floor-reared birds ranged from 0.08% to 3.41% higher.

Table 20. Means and standard deviations of eviscerated weight* in cornish game hens

Protein level (%)	Cage			Floor		
	N	Mean (%)	SD (±)	N	Mean (%)	SD (±)
20	11	65.66	2.37	12	66.63	3.34
22	8	64.19	3.53	10	63.74	8.00
24	11	62.75	2.39	12	66.16	1.58
26	12	66.14	9.84	12	66.22	1.72
Average		64.69[a]			65.69[a]	

* Arcsine percentage transformation for eviscerated weight expressed as a percentage of body weight;
[a] Means with same superscripts are nonsignificant.

The correlation coefficients between percent eviscerated weight and live body weight for each protein level and rearing method are presented in Table 21. The correlation coefficients obtained ranged from -0.192 to +0.475 in cage-reared cornish game hens and from -0.052 to +0.386 in floor-reared birds. Percent eviscerated weight had non-significant correlations to live weight in both cage and floor-reared cornish game hens (Table 21).

Table 21. Correlation between live weight and eviscerated weight (expressed as a percentage of live weight) in cornish game hens

Protein level(%)	Rearing system	Correlation coefficient(r)	Significance
20	Cage	(11)[§] 0.475	NS
	Floor	(12) 0.386	NS
22	Cage	(8) 0.021	NS
	Floor	(10) -0.064	NS
24	Cage	(11) 0.449	NS
	Floor	(12) 0.132	NS
26	Cage	(12) -0.192	NS
	Floor	(12) -0.052	NS

NS, non-significant;
[§] Figures in parentheses are base Ns for the adjacent correlation coefficients.

4.5.2 Broilers:

Table 22 presents the means and standard deviations for percent eviscerated weight on a live weight basis by protein level, age and rearing method. The highest eviscerated weight obtained was 72.51% of live weight for floor-reared broilers and 66.98% for the broilers in cages. In a report by Hathway *et al.* (1953), the eviscerated yields ranged from 68.3% to 73.4% of live weight in broilers. Their studies, however, dealt with 12-week old broilers of different breeds.

When comparisons were made among rearing methods, nonsignificant differences were observed for percent eviscerated weight at both 5 and 6 weeks of age (Table 22).

Table 22. Means and standard deviations of eviscerated weight* in broilers

Protein level (%)	Age (wks)	Cage			Floor		
		N	Mean (%)	SD (±)	N	Mean (%)	SD (±)
20	5	11	66.12	7.78	8	72.51	1.50
22		12	66.35	3.09	11	67.84	2.78
24		12	65.02	2.62	11	67.31	2.63
26		11	63.49	3.04	10	66.12	3.28
Average			65.25[a]			68.45[a]	
20	6	15	66.70	5.91	15	67.94	2.50
22		12	64.84	3.11	16	67.99	2.61
24		13	66.88	3.36	15	66.67	2.38
26		2	66.98	1.40	13	65.84	2.97
Average			66.35[a]			67.11[a]	

* Arcsine percentage transformation for eviscerated weight expressed as a percentage of body weight;
[a] Within age, means with same superscripts are nonsignificant.

The correlation coefficients between percent eviscerated weight and live weight in broilers are shown in Table 23. Nonsignificant correlations were observed between percent eviscerated weight and live weight for cage-reared broilers at 5 and 6 weeks of age. Floor-reared broilers, however, had correlation coefficients significantly different from zero at the 1% level of probability for 20% protein (fifth week) and at the 5% level of probability for 24% and 26% protein (sixth week). Similar findings were reported by McNally and Spicknall (1949) who in their studies observed that the percentage of eviscerated yields became greater as live body weight increased. Jaap *et al.* (1950) also reported a linear relationship between live weight and percentage eviscerated yields.

Table 23. Correlation between live weight and eviscerated weight (expressed as a percentage of live weight) in broilers

		Cage		Floor	
Protein level (%)	Age (wks)	Correlation coefficient (r)	Significance	Correlation coefficient (r)	Significance
20	5	(11)§ -0.375	NS	(8) -0.855	**
22		(12) -0.151	NS	(11) 0.267	NS
24		(12) -0.077	NS	(11) 0.198	NS
26		(11) 0.177	NS	(10) -0.341	NS
20	6	(15) -0.037	NS	(15) 0.189	NS
22		(12) 0.495	NS	(16) -0.026	NS
24		(13) -0.391	NS	(15) 0.605	*
26		(2) 1.000	-	(13) 0.565	*

*P<.05; **P<.01;

§ Figures in parentheses are base Ns for the adjacent correlation coefficients.

4.6 Effects of Slaughtering Methods by Cervical Dislocation or Conventional Method on the Appearance Grade of Cornish Game Hens and Broilers

4.6.1 Cornish Game Hens:

Table 24 lists the effects of slaughter methods on the appearance of carcasses in cornish game hens. These data reveal that in floor-reared birds, cervical dislocation yielded higher percentages (61.29%) of Grade A carcasses than did the conventional method (20.00%). In cage-grown birds, however, conventional method produced greater number (50.00%) of Grade A carcasses compared to cervical dislocation method of slaughter (26.67%).

Table 24. Percentages of cornish game hen carcasses in each grade (based on appearance) for each slaughter method

Rearing	Cage			Floor		
Slaughter method	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
		(%)			(%)	
Cervical	(4) 26.67	(11) 73.33	(0) 0.00	(19) 61.29	(9) 29.03	(3) 9.68
Conventional	(14) 50.00	(13) 46.43	(1) 3.57	(3) 20.00	(7) 46.67	(5) 33.33
Total	(18) 41.86	(24) 55.81	(1) 2.33	(22) 47.83	(16) 34.78	(8) 17.39

Note: Figures in parentheses are base *N*s for the adjacent percentages.

4.6.2 Broilers:

The percentages of broiler carcasses obtained in each grade based on appearance for each slaughter method are demonstrated in Tables 25 & 26. The data indicate that at both 5 and 6 weeks, floor-reared broilers tended to follow the same pattern as the cornish game hens. Cervical dislocation method gave better carcass grade among birds grown on floor. In cage-reared broilers, however, cervical dislocation yielded a greater percentage of Grade A carcasses at 5 weeks of age and conventional method yielded the same at 6 weeks of age.

Table 25. Percentages of five-week old broiler carcasses in each grade for each slaughter method (based on appearance)

Rearing	Cage			Floor		
Slaughter method	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
		(%)			(%)	
Cervical	(5) 41.67	(6) 50.00	(1) 8.33	(20) 74.07	(7) 25.93	(0) 0.00
Conventional	(7) 21.21	(22) 66.67	(4) 12.12	(2) 15.38	(8) 61.54	(3) 23.08
Total	(12) 26.67	(28) 62.22	(5) 11.11	(22) 55.00	(15) 37.50	(3) 7.50

Note: Figures in parentheses are base Ns for the adjacent percentages.

When data from cornish game hens and broilers are compiled together for comparing slaughter methods (Table 27), it appeared that cervical dislocation method produced better carcass quality in terms of appearance than did the conventional method, yielding 14.41% higher of Grade A carcasses (P<.005).

Table 26. Percentages of six-week old broiler carcasses in each grade for each slaughter method (based on appearance)

Rearing	Cage			Floor		
Slaughter method	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
		(%)			(%)	
Cervical	(7) 31.82	(12) 54.54	(3) 13.64	(19) 39.58	(23) 47.92	(6) 12.50
Conventional	(10) 50.00	(10) 50.00	(0) 0.00	(4) 36.36	(7) 63.64	(0) 0.00
Total	(17) 40.48	(22) 52.38	(3) 7.14	(23) 38.98	(30) 50.85	(6) 10.17

Note: Figures in parentheses are base Ns for the adjacent percentages.

Table 27. Effects of slaughter methods on appearance grade in cornish game hens and broilers (combined data)

Slaughter method	Grade A	Grade B	Grade C	Total
		(%)		
Cervical	(74) 47.74	(68) 43.87	(13) 8.39	(155) 100.00
Conventional	(40) 33.33	(67) 55.83	(13) 10.84	(120) 100.00
Total	(114) 41.45	(135) 49.09	(26) 9.45	(275) 100.00

Note: Figures in parentheses are base Ns for the adjacent percentages.

Now the question arises whether the slaughter method accounts for all the differences observed in the percentages of carcasses in each grade based on appearance. The means employed for testing the hypothsis: *carcass grading is independent of slaughter methods* was the Chi-square (X^2) test. The results obtained from the test are presented in Table 28. Although Brant et al. (1982) concluded that stunning was essential for satisfactory bleeding, and Newell and Shaffner (1950) indicated that bleeding enhanced carcass appearance, the result of the statistical analysis (Table 28) eliminated the influence of slaughter methods on appearance grade. The data were consistent with the hypothesis that carcass appearance and slaughter methods are independent. This observation was supported by Heath (1984) who reported that 180 seconds after venesection there is no difference between blood loss of the stunned and non-stunned groups of birds. He further stated that neither the appearance of the carcass nor its keeping quality is affected by different amounts of blood retained in the carcass. He suggested that the muscle capillaries retain their blood after slaughter while all of the bleeding may be from viscera and large blood vessels.

Table 28. Chi-square test of carcass appearance grade

Statistical analysis	DF	Value	Probability
Chi-square	2	5.787 (5.991)†	0.055

†Tabulated values of X^2 are enclosed in parentheses.

Since stunning and thereafter slaughtering of birds by the conventional method showed no advantage over cervical dislocation, and since cervical dislocation, in fact, was found to produce better quality carcass, the present author believes that the feasibility of using this latter method for slaughtering in her own country could be further explored. This need is even strengthened by the fact that in rural Bangladesh electricity needed for stunning is seldom available.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Experiments were conducted with a total of 320 one-day old broiler chicks to determine the effects of different dietary protein levels and rearing methods on the performance and carcass quality of cornish game hens and broilers, and also the influence of slaughter methods on carcass appearance. In this study it was found that:

1. There were no statistically significant differences for live body weights, feed consumption and feed efficiency among the cage- and floor-reared cornish game hens and broilers. In cage-grown cornish game hens and broilers, the groups of birds that were given 20%, 24% or 26% dietary protein were heavier than the group of birds that received the 22% protein diet ($P<.05$). In cage-reared cornish game hens, and also in floor-raised broilers, the groups that fed on 26% protein diet were more efficient in the utilization of feed compared to the groups of birds offered 20% or 24% dietary protein ($P<.05$). Statistical examination, according to the method of analysis of variance showed no significant effects on live weight and feed consumption that were due to dietary protein level and rearing. However, on feed utilization, these effects were significant. The protein

level x rearing interaction was found non-significant for all these parameters evaluated.

2. When comparisons were made among different dietary treatments, 20% protein diet yielded highest percentages of Grade A carcasses in cornish game hens than did the comparable groups fed diets with 22%, 24% or 26% protein ($P<.005$). Overall, rearing chickens on floor produced better quality of carcasses compared to cage system ($P<.05$). In most cases the effects of age, protein level and rearing, and their interactions were found to be significant for various factors (appearance, conformation, fleshing, finish and blisters) of carcass quality.

3. Low non-significant negative correlations were observed between live body weights and incidence of breast blisters in cornish game hens and broilers with the only exception being 5-week old broilers grown in cages. In that latter group, a highly significant negative correlation coefficient was obtained between live weight and breast blisters. A total of 14.61% and 24.19% of cornish game hen and broiler chicks, respectively, had breast blisters.

4. With the exception of 6-week old broilers reared on floor and fed a 22% protein diet, nonsignificant correlations were obtained for percent abdominal fat and live body weight for all dietary protein levels in both cornish game hens and broilers. Nonsignificant differences were found for percent abdominal fat among cage- and floor-reared cornish game hens and broilers. Abdominal fat contributed to a maximum of

1.40% and 1.75% to total live weight in cornish game hens and broilers, respectively. For cage- and floor-reared cornish game hens, 20% and 22% protein diet yielded the highest percentages of abdominal fat respectively. Among broilers, 20% and 26% protein diet produced greater percentages of abdominal fat in cage-grown birds, whereas 22% dietary protein yielded the same in floor-raised chicks.

5. The highest eviscerated weight obtained was 66.63% of live weight for cornish game hens and 72.51% for the broilers. Correlation coefficients between percent eviscerated weight and live weight were significantly different from zero at the 1% level of probability for 20% protein (fifth week) and at the 5% level of probability for 24% and 26% protein (sixth week) in floor-reared broilers. No significant correlations were observed between these parameters in cornish game hens.

6. The cervical dislocation method of slaughter produced better carcass quality in terms of appearance than did the conventional method in cornish game hens and broilers. However, statistical analysis eliminated the influence of slaughter methods on carcass appearance.

One can conclude from the results of this study that rations containing protein as low as 20% will support adequate growth and produce better carcass quality in meat-type chickens reared from day-old to 6 weeks of age. Also, when availability of space becomes a major problem for poultry operations, broilers could be grown feasibly in cages. In this case, formation of blisters can be reduced by using proper flooring materials such as plastic mat or rubber covered nylon (RCN) as suggested by various workers (Lloyd, 1972; Andrews, 1972). If broilers are to be used in further processing, where breast blisters are not a major concern, these could be raised successfully in cages. Cervical dislocation could be further explored as a relatively easy method of slaughtering in commercial processing of poultry in rural Bangladesh.

APPENDIX

APPENDIX

Table I. Means and standard deviations of live body weight in cornish game hens (0-4 weeks)

Protein level(%)	Cage(N=12) Mean (kg)	Cage(N=12) SD (±)	Floor(N=12) Mean (kg)	Floor(N=12) SD (±)
20	0.973	0.050	0.995	0.133
22	0.817	0.166	1.028	0.085
24	0.934	0.098	1.038	0.053
26	0.951	0.123	1.016	0.121

Table II. Means and standard deviations of live body weight in broilers

Protein level(%)	Age (wks)	Cage N	Cage Mean (kg)	Cage SD (±)	Floor N	Floor Mean (kg)	Floor SD (±)
20	5	12	1.349	0.113	12	1.308	0.112
22		12	1.180	0.171	12	1.323	0.065
24		12	1.278	0.166	12	1.320	0.075
26		12	1.271	0.110	12	1.386	0.152
20	6	15	1.767	0.202	15	1.706	0.165
22		12	1.523	0.161	16	1.676	0.125
24		13	1.698	0.102	15	1.694	0.127
26		14	1.715	0.104	13	1.629	0.225

Table III. Means and standard deviations of cumulative feed consumption in cornish game hens (0-4 weeks)

	Cage		Floor	
Protein level(%)	Mean (kg)	SD (±)	Mean (kg)	SD (±)
20	1.781	0.088	1.599	0.087
22	1.408	0.220	1.618	0.074
24	1.815	0.545	1.654	0.074
26	1.521	0.118	1.549	0.055

Table IV. Means and standard deviations of cumulative feed consumption in broilers

		Cage		Floor	
Protein level(%)	Age (wks)	Mean (kg)	SD (±)	Mean (kg)	SD (±)
20	5	2.610	0.093	2.417	0.062
22		2.179	0.462	2.388	0.090
24		2.690	0.871	2.417	0.055
26		2.403	0.190	2.318	0.084
20	6	3.458	0.080	3.445	0.085
22		2.785	0.544	3.347	0.156
24		3.327	0.906	3.414	0.083
26		3.242	0.320	3.241	0.096

Table V. Means and standard deviations of cumulative feed conversion in cornish game hens (0-4 weeks)

Protein level(%)	Cage Mean	Cage SD (±)	Floor Mean	Floor SD (±)
20	1.828	0.079	1.618	0.122
22	1.725	0.069	1.583	0.160
24	1.945	0.550	1.593	0.063
26	1.615	0.188	1.530	0.112

Table VI. Means and standard deviations of cumulative feed conversion in broilers

Protein level(%)	Age (wks)	Cage Mean	Cage SD (±)	Floor Mean	Floor SD (±)
20	5	1.938	0.076	1.850	0.131
22		1.848	0.278	1.805	0.042
24		2.075	0.514	1.830	0.045
26		1.905	0.223	1.678	0.055
20	6	1.964	0.133	2.018	0.058
22		1.963	0.147	2.000	0.048
24		1.998	0.484	2.017	0.017
26		1.883	0.231	1.991	0.016

Table VII. Means of eviscerated(RTC) and abdominal fat(AFT) weights in four-week old cornish game hens

Protein level(%)	Cage N	Cage RTC (kg)	Cage AFT (kg)	Floor N	Floor RTC (kg)	Floor AFT (kg)
20	11	0.594	0.014	12	0.616	0.010
22	8	0.464	0.010	10	0.614	0.014
24	11	0.542	0.011	12	0.638	0.012
26	12	0.580	0.007	12	0.624	0.010

Table VIII. Means of eviscerated(RTC) and abdominal fat(AFT) weights in broilers

Protein level(%)	Age (wks)	Cage N	Cage RTC (kg)	Cage AFT (kg)	Floor N	Floor RTC (kg)	Floor AFT (kg)
20	5	11	0.828	0.024	8	0.839	0.019
22		12	0.726	0.019	11	0.836	0.023
24		12	0.773	0.013	11	0.826	0.013
26		11	0.746	0.015	10	0.858	0.015
20	6	15	1.091	0.025	15	1.073	0.027
22		12	0.921	0.021	16	1.053	0.026
24		13	1.052	0.026	15	1.049	0.025
26		2	1.065	0.020	13	0.999	0.015

Table IX. Percentages of cornish game hen carcasses in each grade, by Protein level and Rearing

Carcass quality factors	20% Grade A	20% Grade B	20% Grade C	22% Grade A	22% Grade B	22% Grade C	24% Grade A	24% Grade B	24% Grade C	26% Grade A	26% Grade B	26% Grade C
Cage												
		(%)			(%)			(%)			(%)	
Appearance	72.7 (8)	27.3 (3)	0.0 (0)	22.2 (2)	77.8 (7)	0.0 (0)	36.4 (4)	54.6 (6)	9.0 (1)	33.3 (4)	66.7 (8)	0.0 (0)
Conformation	45.5 (5)	54.5 (6)	0.0 (0)	11.1 (1)	88.9 (8)	0.0 (0)	0.0 (0)	100.0 (11)	0.0 (0)	16.7 (2)	75.0 (9)	8.3 (1)
Fleshing	45.5 (5)	54.5 (6)	0.0 (0)	11.1 (1)	88.9 (8)	0.0 (0)	9.1 (1)	90.9 (10)	0.0 (0)	8.3 (1)	91.7 (11)	0.0 (0)
Finish	90.9 (10)	9.1 (1)	0.0 (0)	55.6 (5)	44.4 (4)	0.0 (0)	72.7 (8)	27.3 (3)	0.0 (0)	50.0 (6)	50.0 (6)	0.0 (0)
Blisters	90.9 (10)	9.1 (1)	0.0 (0)	66.7 (6)	33.3 (3)	0.0 (0)	81.8 (9)	18.2 (2)	0.0 (0)	41.7 (5)	50.0 (6)	8.3 (1)
Total	69.1 (38)	30.9 (17)	0.0 (0)	33.3 (15)	66.7 (30)	0.0 (0)	40.0 (22)	58.2 (32)	1.8 (1)	30.0 (18)	66.7 (40)	3.3 (2)
Floor												
		(%)			(%)			(%)			(%)	
Appearance	91.7 (11)	8.3 (1)	0.0 (0)	60.0 (6)	40.0 (4)	0.0 (0)	16.7 (2)	50.0 (6)	33.3 (4)	25.0 (3)	41.7 (5)	3.3 (4)
Conformation	91.7 (11)	8.3 (1)	0.0 (0)	80.0 (8)	20.0 (2)	0.0 (0)	66.7 (8)	33.3 (4)	0.0 (0)	75.0 (9)	25.0 (3)	0.0 (0)
Fleshing	91.7 (11)	8.3 (1)	0.0 (0)	70.0 (7)	30.0 (3)	0.0 (0)	75.0 (9)	25.0 (3)	0.0 (0)	58.3 (7)	41.7 (5)	0.0 (0)
Finish	100.0 (12)	0.0 (0)	0.0 (0)	80.0 (8)	20.0 (2)	0.0 (0)	75.0 (9)	25.0 (3)	0.0 (0)	50.0 (6)	50.0 (6)	0.0 (0)
Blisters	100.0 (12)	0.00 (0)	0.0 (0)	100.0 (10)	0.0 (0)	0.0 (0)	100.0 (12)	0.0 (0)	0.0 (0)	100.0 (12)	0.0 (0)	0.0 (0)
Total	95.0 (57)	5.0 (3)	0.0 (0)	78.0 (39)	22.0 (11)	0.0 (0)	66.7 (40)	26.7 (16)	6.6 (4)	61.6 (37)	31.7 (19)	6.7 (4)

Note: Figures in parentheses are base Ns for the adjacent percentages.

Table X. Percentages of broiler carcasses (five-week old) in each grade, by Protein levels and Rearing

Carcass quality factors	Protein levels 20% Grade A	20% B	20% C	22% Grade A	22% B	22% C	24% Grade A	24% B	24% C	26% Grade A	26% B	26% C
Cage												
	(%)			(%)			(%)			(%)		
Appearance	9.0 (1)	54.6 (6)	36.4 (4)	41.7 (5)	58.3 (7)	0.0 (0)	8.3 (1)	83.4 (10)	8.3 (1)	50.0 (5)	50.0 (5)	0.0 (0)
Conformation	45.5 (5)	54.5 (6)	0.0 (0)	50.0 (6)	50.0 (6)	0.0 (0)	16.7 (2)	83.3 (10)	0.0 (0)	20.0 (2)	80.0 (8)	0.0 (0)
Fleshing	54.5 (6)	45.5 (5)	0.0 (0)	50.0 (6)	50.0 (6)	0.0 (0)	41.7 (5)	58.3 (7)	0.0 (0)	30.0 (3)	70.0 (7)	0.0 (0)
Finish	54.5 (6)	45.5 (5)	0.0 (0)	33.3 (4)	66.7 (8)	0.0 (0)	41.7 (5)	58.3 (7)	0.0 (0)	40.0 (4)	60.0 (6)	0.0 (0)
Blisters	54.5 (6)	45.5 (5)	0.0 (0)	83.3 (10)	16.7 (2)	0.0 (0)	58.3 (7)	41.7 (5)	0.0 (0)	80.0 (8)	20.0 (2)	0.0 (0)
Total	43.6 (24)	49.1 (27)	7.3 (4)	51.7 (31)	48.3 (29)	0.0 (0)	33.3 (20)	65.0 (39)	1.7 (1)	44.0 (22)	56.0 (28)	0.0 (0)
Floor												
	(%)			(%)			(%)			(%)		
Appearance	75.0 (6)	25.0 (2)	0.0 (0)	18.2 (2)	63.6 (7)	18.2 (2)	54.6 (6)	36.4 (4)	9.0 (1)	80.0 (8)	20.0 (2)	0.0 (0)
Conformation	75.0 (6)	25.0 (2)	0.0 (0)	81.8 (9)	18.2 (2)	0.0 (0)	90.9 (10)	9.1 (1)	0.0 (0)	100.0 (10)	0.0 (0)	0.0 (0)
Fleshing	75.0 (6)	25.0 (2)	0.0 (0)	72.7 (8)	27.3 (3)	0.0 (0)	90.9 (10)	9.1 (1)	0.0 (0)	100.0 (10)	0.0 (0)	0.0 (0)
Finish	87.5 (7)	12.5 (1)	0.0 (0)	72.7 (8)	27.3 (3)	0.0 (0)	72.7 (8)	27.3 (3)	0.0 (0)	100.0 (10)	0.0 (0)	0.0 (0)
Blisters	87.5 (7)	12.5 (1)	0.0 (0)	100.0 (11)	0.0 (0)	0.0 (0)	100.0 (11)	0.0 (0)	0.0 (0)	100.0 (10)	0.0 (0)	0.0 (0)
Total	80.0 (32)	20.0 (8)	0.0 (0)	69.1 (38)	27.3 (15)	3.6 (2)	81.8 (45)	16.4 (9)	1.8 (1)	96.0 (48)	4.0 (2)	0.0 (0)

Note: Figures in parentheses are base Ns for the adjacent percentages.

Table XI. Percentages of broiler carcasses (six-week old) in each grade, by Protein levels and Rearing

Carcass quality factors	20% A	20% B	20% C	22% A	22% B	22% C	24% A	24% B	24% C	26% A	26% B	26% C
Cage	(%)			(%)			(%)			(%)		
Appearance	46.7 (7)	46.7 (7)	6.6 (1)	25.0 (3)	66.7 (8)	8.3 (1)	38.5 (5)	53.9 (7)	7.6 (1)	100.0 (2)	0.0 (0)	0.0 (0)
Conformation	13.3 (2)	86.7 (13)	0.0 (0)	41.7 (5)	58.3 (7)	0.0 (0)	30.8 (4)	61.5 (8)	7.7 (1)	100.0 (2)	0.0 (0)	0.0 (0)
Fleshing	46.7 (7)	53.3 (8)	0.0 (0)	41.7 (5)	58.3 (7)	0.0 (0)	46.2 (6)	53.8 (7)	0.0 (0)	50.0 (1)	50.0 (1)	0.0 (0)
Finish	66.7 (10)	33.3 (5)	0.0 (0)	50.0 (6)	50.0 (6)	0.0 (0)	69.2 (9)	30.8 (4)	0.0 (0)	100.0 (2)	0.0 (0)	0.0 (0)
Blisters	6.7 (1)	93.3 (14)	0.0 (0)	33.3 (4)	66.7 (8)	0.0 (0)	38.5 (5)	61.5 (8)	0.0 (0)	100.0 (2)	0.0 (0)	0.0 (0)
Total	36.0 (27)	62.7 (47)	1.3 (1)	38.3 (23)	60.0 (36)	1.7 (1)	44.6 (29)	52.3 (34)	3.1 (2)	90.0 (9)	10.0 (1)	0.0 (0)
Floor	(%)			(%)			(%)			(%)		
Appearance	40.0 (6)	60.0 (9)	0.0 (0)	43.8 (7)	50.0 (8)	6.2 (1)	40.0 (6)	46.7 (7)	13.3 (2)	30.8 (4)	46.2 (6)	23.0 (3)
Conformation	93.3 (14)	6.7 (1)	0.0 (0)	87.5 (14)	12.5 (2)	0.0 (0)	93.3 (14)	6.7 (1)	0.0 (0)	76.9 (10)	23.1 (3)	0.0 (0)
Fleshing	86.7 (13)	13.3 (2)	0.0 (0)	87.5 (14)	12.5 (2)	0.0 (0)	73.3 (11)	26.7 (4)	0.0 (0)	76.9 (10)	23.1 (3)	0.0 (0)
Finish	80.0 (12)	20.0 (3)	0.0 (0)	93.8 (15)	6.2 (1)	0.0 (0)	66.7 (10)	33.3 (5)	0.0 (0)	69.2 (9)	30.8 (4)	0.0 (0)
Blisters	100.0 (15)	0.0 (0)	0.0 (0)	100.0 (16)	0.0 (0)	0.0 (0)	100.0 (15)	0.0 (0)	0.0 (0)	100.0 (13)	0.0 (0)	0.0 (0)
Total	80.0 (60)	20.0 (15)	0.0 (0)	82.5 (66)	16.2 (13)	1.3 (1)	74.7 (56)	22.7 (17)	2.6 (2)	70.8 (46)	24.6 (16)	4.6 (3)

Note: Figures in parentheses are base Ns for the adjacent percentages.

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