FAT AND PIGMENT IN RATIONS OF TURKEY FRYER-ROASTERS (BROILERS)

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

Howard E. Wildey

1966

ABSTRACT

FAT AND PIGMENT IN RATIONS OF TURKEY
FRYER-ROASTERS (BROILERS)

by Howard E. Wildey

It has been proposed that large white female poults fail to produce turkey broilers with the desired conformation and adequate finish to stimulate the maximum demand for turkey broilers. It was therefore of interest to evaluate the effect of feeding supplements and pigments on body conformation, appearance and finish, as well as on rate of gain and feed utilization.

Replicate pens of large white female poults were fed 1.5, 4.5 and 4.5 percent of stabilized animal tallow plus a surfactant, starting at 6 weeks of age. The birds were weighed at 2 week intervals and at 11 weeks of age. At 11 weeks of age, one-half of the birds on each treatment were slaughtered; the remainder were slaughtered at 12 weeks of age and the carcasses of both groups were evaluated for finish, conformation and appearance. Body weight and feed conversion data were evaluated but no significant differences were found between the treatment groups. No significant differences were observed in finish, market grade and conformation.

A second trial was conducted in which 0 and 1.5 percent stabilized tallow, were evaluated in combination with no pigmenter, 10 milligrams xanthophyll per pound of feed supplied by Florafil and 10 percent corn gluten meal in the ration. The fat treatments were started when the birds were 2 weeks of age; the pigmenter levels were added at 8 weeks of age. Standards starting and growing rations were modified to prepare the various treatments but protein levels were kept uniform for all treatments for each 2 week growth period. Body weight and feed utilization data were obtained and evaluated for each 2 week growth period. All the birds were slaughtered and dressed, ready-to-cook, at 12 weeks of age. Half of the birds from each treatment pen were dressed at 130° F. and the remainder were processed at 135° F. temperature so as to obtain carcasses with and without the epidermis or skin cuticle.

There was a significant difference ($P < 0.01$) in favor of no added fat when improved body weights at 10 and 12 weeks of age were considered. There was a significant difference ($P < 0.05$) in favor of added fat regarding improved feed utilization for the 10 to 12 week growing period only. The response to diets containing Florafil was not significantly different from that of birds on diets containing no added pigmenter but birds on both of these treatments were significantly better than those on the diets containing corn gluten meal regarding body weight gains. Superior pigmentation of birds fed the diets containing corn gluten meal was observed when the skin cuticle of the carcasses was intact but not when processing procedure removed the skin cuticle from the carcasses. Although the abdominal fat of birds fed corn gluten meal was more highly pigmented than that of birds fed diets containing Florafil or no added pigment, the turkey broilers apparently lacked sufficient fat in their skin to exhibit the yellow pigment when the epidermis was removed. The pigmentation of birds receiving Florafil was no better than that of birds receiving no added pigmenter.

A consumer preference panel evaluated turkey broiler carcasses differing approximately 1 pound in weight and found no significant difference in preference for one sample over the other. Panel studies regarding consumer preference for turkey broiler samples from birds exhibiting yellow pigmented skin and those having the natural white skin revealed a highly significant difference ($P < 0.01$) in favor of the birds with the natural white skin.

FAT AND PIGMENT IN RATIONS OF TURKEY FRYER-ROASTERS (BROILERS)

By

Howard E. Wildey

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Poultry Science

1966

943419

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. Theo H. Coleman, Professor of Poultry Science, for his guidance and interest in this study and his direction and helpful suggestions in the preparation of this manuscript.

The author also appreciates the guidance and help provided by Dr. Philip Schaible, Professor of Poultry Science, for his guidance and direction in the development of the research regarding this study. Special thanks are due Dr. H. C. Zindel and Professor J. A. Davidson of the Poultry Science Department, Dr. L. E. Dawson of the Food Science Department and Dr. H. E. Larzelere of the Department of Agricultural Economics for their guidance and assistance regarding certain phases of the research reported in this manuscript.

The author is also indebted to Dr. C. J. Flegal and Mr. T. L. Barton, of the Poultry Science Department, who contributed substantially to the successful completion of this project.

Thanks also go to Michigan State University, the Department of Poultry Science and the people of Michigan for providing laboratory and farm facilities used in this study.

Chicag

Clinto

this s

patien

Mary E

during

The author wishes to thank the Dawe's Laboratories, Chicago 32, Illinois, and the Clinton Corn Products Co., Clinton, Iowa, for donating special ingredients used in this study.

Finally, the author is warmly appreciative of the patience and encouragement shown by his family, wife, Mary Evelyn; daughter, Mary Marguerite; and son, Edwin, during this important period of study and research.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Female poults are sought by turkey meat producers mainly for the production of consumer size birds, 12 to 14 pound weights, for the holiday market. This situation causes a strong demand for female poults during the months of May, June and July. However, tom poults are in demand generally throughout the year, except in areas where growers avoid starting poults when they would finish the growing period in very hot weather or when they may be subjected to severe winter storms.

The large toms are demanded by both growers and the commercial food trade because of inherent efficiencies in the production and processing of the larger carcasses. The large toms have a favorable feed to meat conversion ratio and the poult and brooding costs are spread over more pounds of meat in the finished carcass. Processing efficiency advantages for the large toms show up as increased tonnage of meat processed plus reduced cost per pound for packaging and other factors related to processing and distributing. The risk to those who hold title to large toms throughout the period of storage is less since the large carcasses are regarded as a stable protein food commodity, accepted by the institutional and restaurant trade as well as the further processing segment of the industry.

This unequal demand for tom and female poults, and the fact that both sexes are hatched in equal numbers, often causes a serious problem in the hatchery segment of the industry. Industry observers doubt that producers could afford to pay $1.30 to $1.50 a poult for sexed toms early in the season to allow female poults to be destroyed. The situation is not quite the same as is the case within the chicken egg industry where the cockerel has no value except for breeding purposes.

Hatcherymen have been dealing with the problem of what to do with female poults during the winter and early spring months by growing out large numbers of the females to light weights as fryer-roasters and/or by offering the day-old poults to producers at favorable prices. Generally the hatcheryman determines an average price per poult, including all costs and desired profit. This amount is multiplied by two and the sale price of the tom poult is subtracted from this amount. The hatcheryman then tries to sell the female poult at the price indicated by the balance. Thus, if a hatcheryman feels he must average a sale price of $.65 per poult and he can sell tom poults for $.78 each, he subtracts $.78 from the average price of two poults or $1.30 and tries to sell the females for the balance, or, as in this case, $.52 each. The large white turkey strains offer advantages in processing and a better appearing carcass when derssed out at immature weights over the Broad Breasted Bronze variety and better feed conversion over the Beltsville Small White variety. White-feathered birds cost less to process because of less noticeable pinfeathers. Birds classified as heavy white breeds or large whites have been greatly improved in recent years for such traits as rapid growth, body conformation and eviscerated yield. They also offer growers the option of raising them to light weights, as fryer-roasters competitive with Beltsville Small Whites, or to maturity, depending on market conditions (Anonymous, 1964a). The large bronze hen has not found favor in the industry as a fryer-roaster due to processing difficulties with pinfeathers though it offers growth efficiencies equal to or better than some large whites and small whites (McCartney, 1952).

There are two schools of thought in the turkey industry regarding turkey fryers: One group holds that the production of turkey fryers (or broilers as they are sometimes designated) is a special business which requires special breeding. Generally, a strain based on the Beltsville Small White variety is used. The eviscerated ready-to-cook carcasses produced from such stock is considered by many processors and retailers to have superior consumer appeal over fryer-roasters produced from large type white females. (There seems to be general agreement that large type male poults are not favored for this type of production because of unfavorable conformation and finish at immature weights.) Breeders and producers of large white strains feel that the female poult from the large white strains will grow into a satisfactory product at less cost for feed due to a more favorable ratio of units of feed required per unit of gain in body weight than that required for the small type white poult. Circumstances already discussed result in favorable and competitive large white female poult prices. The exponents of the large white feel that the large white will adequately serve three purposes for the industry: (1) provide female poults for fryer-roaster production, (2) provide female poults for the production of mature birds for the holiday market, and (3) provide tom poults for the production of heavy toms for the restaurant, institutional and further processing segments of the turkey market.

The size range for the family-size, ready-to-cook turkey fryer-roaster ranges from 5 to 8 pounds. The large white female will usually reach average weights within the upper region of this size continuum by 12 weeks of age with a very favorable feed to meat conversion ratio.

It has been pointed out by Adams (1956) that the increase in turkey "broiler" production and the extensive use of large white poults for turkey broiler production resulted in complaints by some processors and retailers that such stock produces broilers that are inferior in finish and general consumer appeal. Processing techniques

have made it possible to freeze these birds so they will exhibit a uniform light skin color but others in the industry have charged that there is a lack of flavor in turkey broilers fed out using large type poults. The small white type turkey fryer-roaster is marketed at 14 to 16 weeks of age, the toms going to market at 14 weeks of age and the females at 15 to 16 weeks. The large white female fryer-roaster may be too large if fed beyond 12 weeks of age and many birds are large enough to market by 11 weeks of age. However, the small white type broilers appear to develop better finish (more fat in the skin) than the large type birds because of their older age at marketing time.

Looking at developments in the chicken broiler industry, one might conjecture that genetic improvement in large type turkey strains will some day result in birds that will feather and finish to a highly satisfactory degree at 10 to 12 weeks. However, until this can be accomplished through breeding, it seems desirable to develop rations that will attain these ends if they are really perceived as quality factors by the consumer.

Although limited studies have been conducted to evaluate various rations and feed additives in the production of turkey fryer-roasters, few reports are available at present regarding work done with stock now currently available from large white commercial breeders. Some nationally known large white strains are reported to provide average mature weights that exceed that of stock used a few years ago by 1 1/2 to 3 pounds.

An evaluation of the present economic importance of turkey fryer-roaster production can be obtained from data regarding the number of pounds of turkey slaughtered and certified for wholesomeness in federally inspected plants. The quantity of fryer-roaster turkeys certified in this way during 1965 was 105.7 million pounds, ready-to-cook weight. This may be compared to 1,195.0 million pounds of other young turkeys certified in such plants during the same period. Fryer-roaster turkeys represented 0.81 percent of the combined weights of all young turkeys so handled (calculated from data reported in Anonymous, 1966). It is suggested that improvements in the quality of fryer-roaster turkeys would result in increased consumer demand and expanded economic production.

The purpose of this series of experimental trials was to evaluate the market qualities of young, large white turkey females slaughtered while immature at fryer-roaster weights. They were fed specific feedstuffs and feed additives to enhance quality factors such as finish (fat in skin) and yellow pigmentation. Consumer acceptance of these quality traits was evaluated by a consumer panel since the consumer is the ultimate receiver of the product and will determine the economic value of any quality innovation.

REVIEW OF LITERATURE

Davidson et al. (1944) administered diethylstilbestrol and dianisylhexene to turkeys between the ages of 21 and 26 weeks. Diethylstilbestrol was injected into the throat wattle while dianisylhexene was fed in the ration. Two treatment groups of hens showed improvement in fat grade but only the carcasses of males showed improvement regarding pinfeathers. The estrogen treatment usually reduced the final weight of the birds while increasing feed consumption over that of the control groups by 20 to 60 percent. Smith (1949) found that an implant of two 15 milligram diethylstilbestrol pellets was adequate to give superior fleshing and finish and fewer pinfeathers in large toms but there was a growth depression or no growth effect as a result of the treatment. Lane et al. (1951) reported similar results with Broad Breasted Bronze turkeys six months of age.

Jaap and Thayer (1944) fed estrogens to poultry and concluded that the dimethyl ether or diethylstilbestrol is the most potent of those tested and recommended its use in fattening rations. Jaap (1945) demonstrated that there is a distinct difference between the relative potency of some of the estrogenic compounds when fed to chickens and turkeys. Diethylstilbestrol was found to be more active when fed to turkeys than when fed to chickens. The reverse was found to be true upon the oral administration of dienestrol. Thayer et al. (1944) found that the potency of diethylstilbestrol when fed in the ration was insufficient for practical use in fattening chickens. Dimethyl ether of diethylstilbestrol was reported to be extremely potent for fattening when fed to chickens.

Lorenz (1944, 1945) found that diethylstilbestrol pellets implanted in turkeys at 110 and 166 days (approximately 16 and 24 weeks) increased deposition of abdominal fat while similar treatment with chickens markedly increased the fat content of muscle tissue without affecting growth. The optimum treatment period was determined to be from 4 to 6 weeks. Thayer and Davis (1948) fed triphenylchloroethylene and dianisylhexene to young turkeys and observed an improvement in finish due to fattening as well as increased gain. Almquist and Meritt (1952) reported an improvement in gain and feed conversion 4 weeks after 12-week-old Beltsville Small White turkeys were implanted with 15 milligrams diethylstilbestrol pellets. Smyth and Vondell (1955) injected 10 milligrams of diethylstilbestrol in a paste carrier into 8-week-old Jersey Buff and White Holland turkeys. They found that treated turkey fryers of these varieties had heavier weights at 12 weeks of age than the untreated controls and that a growing ration was superior to a finishing ration when fed in conjunction with the estrogen treatment. Growth rate was superior and fat finish was equal to finishing ration. They reported no effect on feed efficiency. A 20.6 percent protein growing ration and a 16.9 percent protein finishing ration were compared.

Adams (1956) compared the response of large white and small white varieties of turkeys, both hens and toms, to a 15 milligram pellet implant of diethylstilbestrol and found that gain and finish were significantly improved in both varieties. He found that the treated large whites were fatter than the untreated Beltsville Whites, showing that hormone treatment can overcome varietal differences in carcass quality. Adams (1957) reported testing both diethylstilbestrol and dienestrol diacetate as growth and fattening aids. Diethylstilbestrol was administered as a pellet (15 milligrams), paste (10 milligrams), oil solution (12.5 milligrams) and liquid (15 to 20 milligrams). All treatments were started 3 weeks before slaughter. He found that diethylstilbestrol as a pellet or paste produced significantly better effect on gain, finish and feed efficiency than liquid or oil solutions. Dienestrol diacetate in the mash at 31.75 milligrams per pound resulted in no favorable effect on gain, only slight improvement in finish and depressed feed efficiency.

Stadelman (1952) implanted 12 milligrams diethylstilbestrol pellets in 7-week-old Broad Breasted Bronze turkeys, with and without thiouracil, and evaluated weight gain, finish and feed conversion at 11 weeks of age when the birds were slaughtered as fryers. This study involved two trials. In the one trial, which was uncomplicated by a disease problem, the treated group required less feed per pound of body weight gained. The mortality due to treatment was important since both trial groups receiving combinations of thiouracil and diethylstilbestrol had much higher mortality than the control group.

Miner et al. (1959) studied the effect of feeding turkey broilers dienestrol diacetate and that of injecting them with diethylstilbestrol and methimazole. Beltsville Small Whites and broad breasted large white turkeys were used in this study. The large variety was found to show more response to the hormone treatment than the small variety. However, the small variety was finished better without hormones than the large whites when treated with hormones. These workers concluded that turkeys of the large variety, with or without hormone treatment, did not attain a satisfactory (Grade A) finish when slaughtered at 13 weeks of age. While the diethylstilbestrol-methimazole treatment improved finish in both varieties, the results with dienestrol diacetate were variable regarding this trait. Their data show that when low protein levels (13 to 16 percent) were fed to broad breasted large white turkeys from 10 to 13 weeks of age, diethylstilbestrol-methimazole treatment gave a significant improvement in weight gain, but only slight improvement was obtained with higher protein levels (19 to 22 percent). The addition of fat to the diet slightly improved weight gain and finish of the Beltsville Small Whites. Dienestrol diacetate (7.94 milligrams per pound of feed) appear to depress weight gain or had no effect. In general, the hormone treatment improved finish in all trials.

Combs et al. (1958) studied the effect of diethylstilbestrol pelleting, dietary fat level and Calorie-protein ratio on growth, feed requirements and quality of 11-week-old Broad Breasted Bronze turkey fryers fed to 14 weeks of age. Treatments included rations containing 2 or 10 percent added stabilized fat with a Calorie-protein ratio of 44:1, with or without implantation of 15 milligram pellets of diethylstilbestrol. A further comparison was made with rations containing 2 or 10 percent added fat with a Calorie-protein ratio of 60:1 but without the hormone.

Birds implanted with the hormone gained weight more rapidly and had significantly greater finish scores than the controls, but without significant differences in feed efficiency or intake of energy or protein per 100 grams of weight gain. Only slight differences in weight gains were noted between diets containing 2 or 10 percent added fat with and without the hormone implant. The quality of fryers receiving rations containing 10 percent added fat was not significantly different from those fed a ration containing 2 percent added fat, but growth rate was improved and feed requirement was reduced when 10 percent added fat was in the ration. The rations with the 1:60 Calorie-protein ratio gave significantly greater dressed finish scores and greater abdominal fat and drip loss. Taste panel results showed no significant difference regarding acceptability of the meat from the different treatment groups.

Carter et al. (1958) studied the effects of oral administration of estrogens on growth, feed conversion and carcass quality. The effect of different levels of dienestrol diacetate and length of time of feeding period and the comparative effects of dienestrol diacetate and diethylstilbestrol when included in the ration of turkey broilers were evaluated with and without 5 percent added fat. Two trials were conducted in this experiment. In Trial 1, dienestrol diacetate significantly improved weight gains of Beltsville Small White turkeys when included in the diet at the level of 22 to 32 milligrams per pound of ration fed for 3 or 6 weeks before marketing at 16 weeks of age. The only significant improvement in finish was in males fed 22 milligrams of dienestrol diacetate per pound of feed for either 3 or 6 weeks. In Trial 2, dienestrol diacetate had no effect on weight gains, but diethylstilbestrol significantly improved weight gain of small white type turkeys when fed from 9 to 12 weeks of age. The addition of 5 percent animal fat had no effect on weight gain. In this trial, the feeding of 5 percent added fat alone or in combination with either of the estrogens, failed to produce any observable difference in market quality. The authors concluded that the difference between the ages of the birds in the 2 trials may have influenced the response of the birds to the treatment.

Creiger et al. (1960) studied the effect of oral administration of diethylstilbestrol and dienestrol diacetate on growth rate and feed efficiency of Beltsville Small White turkey broilers. He found that the feeding of diethylstilbestrol in the diet of 10-week-old Beltsville Small White broiler turkeys failed to improve feed efficiency and only slightly increased weight gains. The incorporation of dienestrol diacetate in the ration significantly improved weight gains when fed over a 4 week period and feed efficiency was improved. The addition of fat in either experiment did not significantly improve weight gains unless the diet also contained estrogens. However, fat alone in the diet improved feed efficiency.

Bird et al. (1948) found that the composition of the ration accompanying either orally or subcutaneously administered estrogens is an important factor in fat deposition in chickens. Treated birds fed a 14 percent ration gained less weight but showed more fat deposition than did those fed an 18 percent protein ration.

Summary of Literature Review on Hormone Use to Enhance Finish

The findings of Davidson et al. (1944) and Jaap and Thayer (1944) that estrogens or estrogen-like hormones increased finish in turkeys and chickens were confirmed in general by the other research results cited. Growth was generally found to be reduced or unaffected by hormone treatment unless fat was added to the diet (Combs et al., 1958) or the diet protein level was low (Miner et al., 1959; Bird et al., 1948). However, restrictions in effect at the time of this study prohibiting the use of estrogen hormones in poultry and turkey feeding were deemed adequate reason for seeking other means by which the finish and other factors of market quality might be enhanced in turkey broilers produced from large white type female poults.

Dietary Energy and Protein Relationships

The studies of Scott et al. (1947) revealed that rations high in energy content generally promoted more rapid growth and better feed efficiency in chickens than rations of lower energy content. When stabilized fats and greases became available for use in poultry feeds, even higher energy levels were made possible and studies were initiated to explore the relationship between energy and protein ratios in the ration. Hill and Dansky (1950) in studying the relationship of the protein requirements of chicks to dietary energy level found that growth was depressed when a high-energy-low-protein ration was fed; growth was improved with this ration when the energy level was lowered. Aitkin et al. (1954), in a study of the use of beef tallow as a source of energy in broiler rations, fed beef tallow to chicken broilers to 10 weeks of age, after which the birds were slaughtered and graded for finish by official government graders. Two diets were used containing 22 and 25 percent protein, respectively. The addition of 10 percent tallow to the ration containing 22 percent protein failed to give a significant increase in growth rate and gave only a slight improvement in feed efficiency. However, the addition of 10 percent tallow to the 25 percent protein ration gave a highly significant increase in growth rate and an 8 percent improvement in feed efficiency. The diet containing 25 percent protein and 10 percent added beef tallow produced broilers with finish superior to that of birds fed the other diets. A consumer preference panel preferred the birds fed rations containing tallow because of perceived moistness in the cooked meat though no difference was noted in the flavor of the meat from the birds on all the diets.

Hill and Dansky (1954) studied the effect of dietary energy level on growth and feed consumption. Crossbred chicks were fed rations with energy levels ranging from 75 to 505 Calories per pound of ration (using pulverized oat hulls up to 40 percent of the ration). They obtained maximum growth rate as measured by body weight and shank length with a ration containing an energy level of 623 Calories per pound. They observed that feed consumption was determined by the energy content of the ration and concluded that protein level in the ration had little or no effect on feed consumption. Maximum growth rate at low dietary energy levels was associated with marked increases in feed consumption. Though the birds increased feed consumption their total energy intake was decreased progressively as the dietary energy level of the diet was decreased. The energy level of the diet was reflected in the fat content of the carcasses. The chicks fed the ration highest in energy concentration had the highest carcass fat content, and fat content was progressively lower as the energy level of the ration and total energy intake declined.

Sunde (1954), in experiments conducted to evaluate the use of animal fats in poultry feed, found no consistent improvement in growth when white grease, prime tallow, and soybean oil at 2.2 and 5.0 percent levels were added to rations fed to chickens. The same levels of these fats when added to turkey rations showed growth improvement only when prime tallow was used. Feed utilization was improved with both chickens and turkeys when the various fat levels were fed. The addition of fat to poultry feeds reduced the amount of dust and improved the texture and color of the feed. Sunde (1956a) conducted four experiments with crossbred chicks to determine the importance of energy-protein relationships. Diets containing 20 and 28 percent protein were supplemented with 0.5 and 10 percent white grease. Energy levels of 655, 730, 771, 806, 845 and 932 productive Calories per pound of ration were used. He found that a high protein-low energy diet caused a reduction in the growth rate and in feed efficiency. Raising the energy level of this type of diet by adding fat improved both growth and feed efficiency. He concluded that the data suggested that changing the protein level changed the optimal energy:protein ratio.

Carver et al. (1955) studied the utilization of fats of different melting points when added to broiler feed. These workers determined the extent of absorption of tallow, hydrogenated tallow, fatty acids from hydrogenated tallow, and oleic acid by the chick. Neither hydrogenated tallow nor hydrogenated tallow fatty acids are effectively utilized as fat supplements to broiler feed. Unmodified tallow is well absorbed, 82 to 100 percent.

The chicks readily hydrolyzed as much as 90 percent of the fats fed; hence, a lack of digestion does not account for the poor absorption of hydrogenated fats. The hydrogenated fat and fatty acids did not improve 4 week feed conversion while tallow improved feed conversion in these experiments.

Cullen et al. (1962) studied the metabolizable energy values and utilization of different types and grades of fat by the chicken. The metabolizable energy, absorbability and effect on growth and feed conversion were measured on a number of fat samples including different grades of tallows and greases, hydrolyzed animal and vegetable fat, methylester and fatty acids when fed to chicks. The results showed that feed conversion was improved by all fats used in the test. The authors concluded that any of the grades of animal fat or hydrolyzed animal and vegetable fat that are commonly found on the market will give satisfactory feeding results.

Donaldson et al. (1956) experimented with chickens reared to 4 weeks of age and found that the productive energy level in the ration influenced the protein level required in relation to rate of growth, feed consumption and body composition. Energy intake and carcass fat deposition were increased and water content of the carcass was decreased as the Calorie:protein ratio in the ration was widened. The results showed that feed conversion and growth were impared when the ratio of Calories of productive energy per pound for each percent protein exceeded 43.9, 48.6 and 53.7 on the low, medium and high fat diets, respectively. A wider ratio of productive energy to protein in the ration was tolerated without adversely affecting growth rate, as the proportion of the Calories from dietary fat to those from other sources was increased. As the energy:protein ratio of the ration was increased, less protein and more energy were required per unit of gain.

The authors offered two possible explanations as to why the chicks fed rations containing added fat could tolerate wider Calorie:protein ratios before growth was adversely affected than could the control chicks. They proposed that a specific effect of fat in metabolism might involve an increased ability of the chick to convert energy from added fat in the diet into body fat, thus permitting a greater increase in dietary energy intake when diets contained less than optimal protein levels. They also offered the possibility that the proportion of energy obtained from fats _versus_ carbohydrates might exert a physiological effect on the bird affecting its appetite.

Potter _et al_. (1956) worked with poultry rations containing varying protein levels from 20 to 30 percent combined with varying Calorie:protein ratios from 32:1 to 56:1 to determine the effect of these combinations on growth and feed efficiency. Each of 32 diets was fed to 18 crossbred chicks, in batteries, through 6 weeks of age. As the productive energy and protein increased in diets of a constant Calorie:protein ratio (32:1 to 56:1), or as the Calorie:protein ratio increased in diets of a constant protein content (from 20 to 30 percent) growth rate consistently increased until the diet energy level was approximately 1150 Calories and feed efficiency increased throughout the experiment. These researchers concluded that both chick growth rate and feed efficiency were more closely related to productive energy level than they were to the Calorie: protein ratio.

Dymsza et al. (1953) studied the response of growing turkeys to variation in the fiber and energy content of mash and pelleted diets. Diets containing 5, 10 and 20 percent fiber supplied principally by adding oat hulls were fed as mash and as pellets to floor-reared 10-week-old White Holland turkeys. The dietary energy level varied from 245 to 875 Calories per pound. All turkeys except those fed the 20 percent fiber diet as mash made satisfactory gains and produced carcasses of good quality at 27 weeks. Pelleting of feed generally increased body weight, efficiency of feed utilization and dressed carcass score. The benefits of pelleting were progressively greater as the fiber level increased and were more apparent in males than in females. Increased fiber levels retarded feather pulling. These workers concluded that the productive energy requirements of growing turkeys, 10 weeks of age and older, seemed to fall within the range of 460 to 875 plus Calories per pound of feed. High fiber diets were found to stimulate feed and water consumption causing wet litter. Dymsza et al. (1955) fed poults 28 percent protein diets with energy levels of 744, 539 and 341 Calories per pound with fiber levels of 5, 10 and 15 percent, respectively. The heaviest poults of both sexes were produced with diets containing 744 Calories of productive energy per pound. The calculated energy to protein ratio was 26.5 to 1.

Biely and March (1954) carried out four experiments to study the relationship between optimum protein and fat levels in chick and poult rations. They observed that the addition of fat to a 19 percent protein diet depressed growth and feed efficiency in chickens. However, when fat was added to 24 percent or a 28 percent protein diet, growth was not affected or was stimulated and feed efficiency was improved. Supplementing the diet with tallow increased the level of protein which might be expected to give maximum growth to 7 to 8 weeks. A 28 percent protein diet containing 5.0 or 7.5 percent tallow and supplemented with aureomycin produced the fastest growth to 7 weeks of age.

Broad Breasted Bronze poults grew faster when the ration was maintained at 28 percent protein than when it was gradually reduced to 20 percent. This was true with and without added tallow. The growth rate of the birds was increased by the addition of tallow, particularly in the ration maintained at 28 percent protein. The authors concluded that the addition of fat in both chick and poult rations may be advantageous when relatively high levels of protein are fed. When the energy content of the diet is raised by the addition of fat, the level of protein which can be utilized efficiently is raised also.

Baylock et al. (1954) studied the effect of energy level of the diet on growth, feed efficiency and degree of fattening of turkeys. Broad Breasted Bronze turkeys were grown to 8 weeks of age under practical conditions and then placed on test. They were divided by sex into 12 groups of approximately 50 birds each. The birds were fed high and low energy pellets with grain. There were no differences in the average finish scores or commercial grades of hens fed the various diets. However, the toms fed the low energy pellets and corn had poorer scores and lower percentages of Grade A birds than toms fed the higher energy diets.

Lockhart and Thayer (1955) used poult diets with various protein and energy levels supplemented with lysine and methionine to study energy-protein relationships in turkey poult starters. Turkey starter rations were fed containing 22, 24, 26, 28 and 30 percent protein. Each protein level was fed with three available dietary energy levels, 720, 800 and 880 Calories per pound of ration, respectively. Lysine and methionine were added to the rations in the series which contained protein levels of 22 and 26 percent and an available dietary energy level of 800 Calories per pound. These workers reported that the heaviest weights were obtained with a 30 percent protein diet containing 880 Calories of available energy per pound. The authors concluded from other data, however, that maximum growth was not being obtained during the 4 week test period during which this ration was fed. The addition of methionine to the 22 percent protein ration significantly increased rate of gain but no additional gain was obtained by supplementing the ration with lysine. The addition of a combination of lysine and methionine to the 26 percent protein level ration substantially increased gain but only a slight increase in gain occurred when methionine or lysine was added individually.

Ferguson et al. (1956a) studied the effect of amino acid supplements to the diet of Broad Breasted Bronze turkey poults fed various levels of protein and productive energy to 8 weeks of age. A total of 828 Broad Breasted Bronze turkey poults were distributed at random into 18 groups of 46 birds each for this experiment. Methionine, tryptophane and lysine were added to diets which contained 21.7, 24.8 and 28.6 percent protein and had been calculated to contain 825, 774 and 716 Calories per pound, respectively. These researchers reported that poults fed a 24.8 percent protein diet containing 774 Calories of productive energy per pound and supplemented with methionine or tryptophane produced the best growth. They reported that a Calorie-protein ratio of 25:1 gave the best growth of poults with a 28 percent protein diet not supplemented with amino acids, but the diet appeared to be low in energy. The authors found that the optimum growth response was produced with a 24.8 percent protein diet supplemented with methionine or methionine and tryptophane with a Calorie:protein ratio of 31:1. The results of this experiment indicate that the amino acid levels supplied by the 21.7 and 24.8 percent protein diets were not high enough to provide optimum growth. The data indicated that methionine is the first limiting amino acid since 7 out of 8 of the groups receiving methionine produced heavier poults at respective protein levels.

Ferguson et al. (1956b) studied the effect of feeding Broad Breasted Bronze turkey poults a 26 percent protein diet with varying levels of productive energy. The calculated productive energy levels tested were 670, 739, 797, 739, 802 and 865 Calories per pound of ration. The best growth at 8 weeks of age was obtained with males and females fed a diet containing a Calorie-protein ratio of approximately 29:1.

Baldini et al. (1954) in a study of the protein requirements of turkey poults demonstrated that poults would grow at a normal rate to 6 weeks of age on a properly supplemented 20 percent protein diet. This was considerably less than the 28 percent protein level suggested by the National Research Council in 1950. These researchers found that lysine and methionine are the first and second limiting amino acids, respectively in a 20 percent protein corn-soybean oil meal poult diet. However, they found evidence regarding growth rate indicating that methionine is the limiting amino acid in a 28 percent protein corn-soybean oil meal poult diet. Condensed fish solubles and procaine penicillin were found to be valuable supplements in low protein corn-soybean poult diets. Baldini and Rosenberg (1955; 1957) demonstrated that the methionine level in the feed must be increased as the energy level of a ration increases. The results of these studies indicated that the nutritional effect of fat in a diet containing adequate amounts of essential fatty acids was due to the Caloric value of the fat. These workers found that growth, feed conversion and body composition were not affected by increasing the fat content of the diet when the Caloric value of the diet was held constant.

Yacowitz et al. (1956), Carter et al. (1957) and Carter and Wyne (1956) found that Calorie-protein ratios from 33 to 60:1 did not affect the growth rate of poults between 8 and 16 weeks of age but the addition of fat to the diet improved feed utilization. Yacowitz et al. (1956) fed turkey broilers a turkey starter ration supplemented with 2.5 percent stabilized animal fat and 3 percent fish solubles to 9 weeks of age. After 9 weeks of age, the birds were started on experimental treatments. Levels of 0, 3 and 6 percent stabilized animal fat were used in combination with calculated protein levels of 20, 23 and 26 percent. These workers reported that there were significant differences among groups of males fed the various levels of fat but there were no significant differences among groups of males receiving 20, 23 and

26 percent protein. The interaction between protein and fat levels alone significantly affected female weights at 16 weeks. None of the rations had any measurable effect on market quality as judged by handling the live birds at 16 weeks. The authors concluded from their results that the 20 percent protein level was adequate for turkeys 8 to 16 weeks of age with rations containing up to 6 percent added fat and 937 Calories of productive energy per pound.

Carter et al. (1957) conducted two experiments to study the effect of dietary energy on growth and feed conversion of turkeys from 8 to 16 weeks of age. In the first test, 450 small type white turkey poults were fed from 8 to 16 weeks of age on rations containing 17, 20 and 23 percent protein, each with and without 3 and 6 percent stabilized animal fat. The second experiment was similar except that large type poults were used and the protein levels used were 14, 17 and 20 percent with the same additions of fat. These workers found that with small type turkeys, 7 to 10 pound weight at 16 weeks, rations containing 17 percent protein and up to 6 percent animal fat with an energy level of 1004 Calories per pound were adequate for growth at this age. Efficiency of feed conversion was improved at each protein level as the energy value of the ration was increased. However, with the heavy type turkeys, 9 to 12 1/2 pounds, 14 and 17 percent protein did not support normal growth. The authors concluded that a ration containing 20 percent protein with up to 6 percent animal fat and supplying 957 Calories of productive energy per pound is required for the large type poults. Feed efficiency was improved when fat was added to rations containing 14 percent protein but not with rations containing higher protein levels.

Atkinson _et al_. (1957) conducted three experiments feeding turkey poults to 8 weeks of age to evaluate protein and energy levels for turkey starting diets. Diets containing 26, 28, 30 and 32 percent protein were each tested with three levels of productive energy giving energy:protein ratios (Calories productive energy per pound to each 1 percent of protein in the ration) of 24:1, 27:1 and 30:1. Stabilized animal fat was used to regulate the energy level replacing some soybean oil meal and grain. In trials in which fat was used, growth rate and feed efficiency were significantly improved as the percentage of protein in the diet was increased. Also, in these trials, with each protein level, growth and efficiency improved as the energy value of the diet increased. However, it was observed that at the higher levels of protein, the energy:protein ratio was of less significance for growth than at the lower levels. The protein requirement per gram weight gain was less when the productive energy of the diet within each protein level was increased.

The authors suggested that it may be advisable to start poults on a high protein ration, 30 or 32 percent, supplying at least 720 Calories of productive energy per pound, and to reduce it after a week to 10 days to 28 percent protein with 840 Calories per pound.

Waibel (1958) studied the effectiveness of unknown growth factors, antibiotics and animal fat in turkey poult rations and concluded from his data that supplementation of "complete" poult diets with animal fat resulted in a marked growth response and improvement in feed efficiency, provided the protein level was adequate. The experiment included 24, 28 and 32 percent protein levels. A protein level of 28 percent was in all trials superior to a level of 24 percent. The 28 percent protein diets produced a growth rate equal to that of 32 percent protein diets in this study. Growth was further improved when 10 percent of animal fat was added to rations containing high levels of protein.

Early in the hatching season, unknown growth factors provided by 6 percent fish meal, 3 percent alfalfa meal, 3 percent distillers dried solubles and 2 percent whey added to corn-soybean oil meal diets fed to turkey poults, produced only small growth increments. However, when these supplements were added factorially to a corn-soybean meal basal turkey poult diet and fed to poults hatched from eggs produced late in the hatching season, each supplement produced highly significant and independent growth responses.

The performance of turkey market stock is determined by many management factors but recent research has emphasized the interdependence of breeding and nutrition where gain and efficient feed utilization are the criteria being measured. Thayer et al. (1961) in a study of energy and protein interrelationships in turkey grower diets, using a semi-purified all-mash diet, produced 12 pound market weight hens in approximately 19 weeks on 2.1 pounds of feed per pound of gain and 24 pound market weight toms in 24 weeks on 2.3 pounds of feed per pound of gain. A commercial strain of Broad White turkeys was used in this experiment. A related study of Dunkelgod et al. (1961) in which a commercial Broad Breasted Bronze strain of turkeys was used, showed that market weight hens with an average body weight of 12 pounds were produced in 16 weeks on 1.95 pounds of feed per pound of gain. A comparison of the results obtained in the two feeding trials shows that the growing period was reduced in time by approximately 3 weeks in the latter trial. The authors attributed these results to a greater potential for gorwth in the strain of turkeys used and a more adequate nutrient balance in the daily nutrient intake.

Summary of Review of Literature Regarding Dietary Energy and Protein Relationships

The idea that growth and feed utilization are increased by raising the energy level of broiler diets, as demonstrated by Scott et al. (1947), has been confirmed by the research results cited. The attempts to increase the energy content and density of poultry rations through the use of vegetable and animal fats as reflected in the work of Aitkin et al. (1954), Hill and Dansky (1954) and Sunde (1945; 1956a and 1956b) have generally produced diets that enhance feed conversion, gain and, sometimes, finish.

The findings of Carver et al. (1955) and Cullen et al. (1962) have established the practicability of feeding poultry the vegetable and animal fats generally available to the feed industry as sources of energy when the cost of these ingredients makes this practice economically feasible.

Dymsza et al. (1953) working with turkeys, demonstrated the beneficial effect of increasing nutrient density using varied levels of fiber and pelleting of the diet.

The use of fat with increased levels of protein has been demonstrated consistently to improve the growth rate of turkey poults. The addition of fat to the diet with an accompanying increase in energy level increases the level of protein which may be considered to give maximum growth (Biely and March, 1954). These findings have been supported in the literature cited from Baylock et al. (1954), Lockhart and Thayer (1955), Ferguson et al. (1956a; 1956b) and Atkinson et al. (1957). However, Baldini and Rosenburg (1955) found that the improved nutritional effect of fat in a diet containing adequate amounts of essential fatty acids was due solely to the Calorie value of the fat.

The work of Baldini et al. (1954), Lochart and Thayer (1955), and Ferguson et al. (1956a) emphasized the importance of the amino acid balance in the poult diet by supplementing relatively low protein diets with the important amino acids, methionine and lysine. The conclusion of Weibel (1958) that supplementation of "complete" poult diets with animal fat resulted in a marked growth response and improvement in feed efficiency, provided the protein level was adequate, may well sum up the findings of this literature regarding fat in the poult diet and it seems equally applicable to the chick diet, too.

Surfactant Studies

Growth stimulation in chicks following the feeding of certain synthetic detergents, such as are commonly used in household washing preparations, was reported by Ely (1951). He found that the inclusion of lauryl ethelene oxide condensate, a surface-active compound, stimulated the growth of chicks to a significant degree, in some cases as great as 10 percent. A search of the literature revealed that only a relatively few reports have been published indicating general negative results in much of the experimental work stimulated by this initial work. According to Flett (1942), detergents or surfactants as they are more technically called refer to those agents which have an unusual surface active action. This activity comes from their ability to coat over surfaces with layers so thin that they do not visibly change the coated material. The material so coated no longer presents its own surface to a surrounding solution, with the result that its properties in solution are changed. Neidig and Hersberger (1952) estimated there were 700 to 800 surface active agents available commercially in the United States at that time. According to these authors the industry has standardized on a broad classification of surface active agents as anionic, cationic and nonionic. The cationics are largely used because of their germicidal properties. The anionic and nonionic surfactants have uses comparable with soap. The types of synthetics classified as anionic are: alkyl aryl sulfonates, alcohol sulfates and miscellaneous sulfates and sulfonates. Those classified as nonionic are: alkyl phenalethylene oxide type, aliphatec polyhydric alcohol esters and fatty acid amides. The nonionics are generally liquids and do not have the high foaming characteristics of the anionics. According to Ely (1951) the first mentioned group (the cationic compounds which have a germicidal nature) produce growth responses during the early weeks in chicks or at about the same time as the antibiotics but generally do not give the dramatic responses of the better antibiotics. It was his opinion that the action of this type of surfactant was basically the same as that of the antibiotics in that both modify the intestinal microflora. The second group of surfactants, the emulsifying and wetting agents, he believed to have a different effect on growth. He found that these materials promoted extra gains during the latter weeks in the case of broilers (6th to 12th week). Ely suggested this reaction may be a physical phenomenon in which more favorable conditions for the assimilation of nutrients from the digestive tract are achieved.

Anson (1939) suggested that detergents might act as physiological substitutes for bile salts. He stated:

> Physiologically, the bile salts emulsify fats, activate lipase and promote the absorption of various substances. The possibility must now be considered that the physiological reactions of the bile salts, like their reactions with proteins, depends not on their specific structures, but on their general hydrophobic-hydrophilic character, and that other substances with the same general hydrophobic-hydrophilic character can act as physiological substitutes for the bile salts.

The reported results of feeding surfactants to other animals and poultry in the literature do not consistently support the results reported by Ely (1951). Ely and Schott (1952) provided a possible, partial explanation for these different results when they emphasized that the favorable response to the feeding of surfactants to chicks could not be detected until after the birds were 5 to 6 weeks of age.

Harris et al. (1951) found that the growth of rats was inhibited when these animals were fed diets containing high levels of certain surfactants. However, Leucke et al. (1952) found that the surfactant, Ethomid C/15, gave a 36 percent increase in growth when fed to young pigs. This response was equal to that obtained by feeding aureomycin. Scott et al. (1952) fed this same surfactant to chicks and failed to stimulate chick growth up to 28 days. In this test the Ethomid C/15 was one of a group of six surfactants tested including both cationic and nonionic surfactants. The addition of aureomycin to the basal diet greatly accelerated chick growth but in no case was growth stimulated by supplementing the basal diet with a surfactant. In one trial the combination of surfactants sharply depressed growth. The authors observed a small incidence of perosis in chicks receiving the surfactants and expressed the opinion that this should not be ignored even though the number of affected birds among the 25 used in each test pen was small. Out of 8 pens, 2 had zero perotic birds, 3 pens had 1 perotic bird each, 2 pens 2 affected chicks each and 1 pen fed 0.1 percent Ethomid C/15 had 4 perotic chicks. All surfactants were fed at the 0.1 percent level.

Stern and McGinnis (1953) compared the growth response of chicks to detergents, germicides and penicillin and failed to obtain growth stimulation up to 4 weeks of age. Snyder et al. (1953) fed the surfactant (Ethomid C/15) used by Scott et al. (1952) and by Leucke et al. (1952) along with other surfactants over a 10 week test period without significantly improving growth.

Biely et al. (1954) studied the effects of including 6 percent of herring oil, 150 milligrams per pound of iodinated casein, and 0.1 percent of a commercial surfactant (Santomerse-80) individually and in combinations in a laying ration. The surfactant agent was used in an effort to increase fat utilization. The supplements were added to a practical laying ration and fed to White Leghorn pullets in individual cages. The 6 percent of oil did not affect the rate of production; however, the birds receiving this oil attained heavier weights than birds receiving rations without the herring oil. The addition of iodinated casein to the ration produced lighter birds but the inclusion of 6 percent fat overcame this depression. The supplementation of the diet with and without herring oil with Santomerse-80 resulted in better feed efficiency for egg production in both cases.

Pigmentation Studies

A search of the literature failed to reveal reports of work related to the development of yellow pigment in the skin of turkeys. However, considerable work related to this subject has been done with chicken broilers.

Research by Palmer (1915), Heiman and Tighe (1943) and Fritz et al. (1957) has demonstrated that the degree of pigmentation in broilers is controlled primarily by the level of pigmenting substance (xanthophyll) in the ration. Palmer (1915) first demonstrated that xanthophyll is the principal yellow pigment of the chicken body fat, egg yolk and blood serum and pigmentation generally was proportional to the pigment in the feed. Certain feed ingredients have been shown to limit pigmentation. Hammond and Harshaw (1941) found that fortified cod liver oil, cod liver oil and sardine oil at high levels suppressed pigment. However the levels required to do this were beyond levels for practical application based on present practices.

Conflicting results have been reported concerning the effectiveness of feeding antioxidents in the ration to enhance pigmentation. An improvement in pigmentation by the use of diphenyl-p-phenylenediamine (DPPD) has been reported by Potter et al. (1956) and Fritz et al. (1957). Harm et al. (1958) reported that the addition of DPPD to broiler rations significantly depressed pigmentation. Potter et al. (1956) reported a slight improvement in pigmentation when dietertiary-butylpara-cresal (BHT) was included in the ration.

House (1957) determined that 9.5 to 10.0 milligrams of exanthophyll per pound of ration was necessary for adequate pigmentation of broilers. Fritz et al. (1957)

considered 12.5 milligrams of xanthophyll per pound of ration adequate to produce good pigmentation. According to Day and Williams (1958), the work of Hill and Dansky (1951) and Maw (1939) developed evidence indicating a positive relationship between carcass fat and pigment deposition.

Carver (1959) found that yellow grease, No. 1 tallow, hydrolyzed animal and vegetable fat, and methyl esters of vegetable fat reduced pigmentation when included in rations bed to broilers. Ratcliff et al. (1959) found that changing The Calorie-protein ratio of rations in a range from 35 through 60 had no important influence on broiler pigmentation.

Day and Williams (1958) found that the addition of BHT to the ration at the 0.0125 percent and 0.025 percent levels reduced pigmentation somewhat in most trials. Their data showed that stabilized beef tallow at a 5 percent level significantly increased the utilization of xanthophyll when it replaced an equal amount of white corn in broiler rations. These workers found the xanthophyll in alfalfa meal and corn gluten meal to be utilized about equally well for pigmentation in broilers. The xanthophyll in yellow corn was found to be more efficiently utilized for pigmentation than the xanthophyll supplied by corn gluten meal and alfalfa meal. Commercial xanthophyll concentrates were found not to be as effective as alfalfa when compared on the basis of their respective levels of xanthophyll. They found that adequate pigmentation was obtained with broilers when as little as 6.25 milligrams of xanthophyll per pound of ration was fed provided a portion of the pigment came from yellow corn. The authors suggested that when alfalfa meal, corn gluten meal or a combination of these two feedstuffs is used as the source of xanthophyll, the dietary level needed for good pigmentation may be somewhat higher. Xanthophyll was reported to be more effective in increasing pigmentation when fed during the latter weeks of the growing period.

Studies Related to Consumer Preference

Studies by Mills *et al*. (1961) have demonstrated that the consumer is influenced favorably or unfavorably toward turkey by the grade label placed on the carcass. Consumers reacted favorably to grade labels, "Prime," "Choice," and "Good" as labels for whole turkeys as well as for raw turkey parts and cooked turkey products. This study revealed that consumers preferred the word label "Choice" to the letter grade "Grade A." The word grade label "Good" was preferred to the letter label "Grade B."

Makens (1960) found that consumers consistently preferred birds labeled as hens to those labeled toms during panel studies. He concluded that mandatory sex labeling could result in a decreased demand for toms sold through retail stores to consumers with a resulting decrease in price and lower marketing margins. This would bring about an unnecessary economic loss to the turkey industry.

Studies by Makens (1963) explored the effect of brands on consumer packages of turkey. It was his conclusion that brands did "differentiate turkeys of similar weight and quality in terms of consumer preference." This researcher evaluated the extent of market segments which are favorably and unfavorably affected by brands. The portion of the consumers favorably affected by brands were divided into segments who would be willing to pay a premium for a specific brand. The findings of the research showed that 20 to 25 percent of the consumers involved were willing to pay a premium for a well-known brand. As many as 33 percent demonstrated a willingness to pay as much as $.05 per pound extra for a preferred brand. Approximately 60 percent of the consumers consistently preferred a popular well-known brand to unknown brands of similar weight and apparent quality.

Brand names appeared to help consumers make decisions between products when they were unable to observe differences in the quality of the competing turkeys. However, personal inspection appeared to be the most important factor involved in the selection of turkeys. One brand caused consumers to discriminate against the turkeys sold under it and green appeared to be an undesirable label color. A brand label which obscured too much of the turkey breast from inspection by the consumer appeared to meet with consumer disfavor. A well-known brand in the market area was not always preferred by consumers over an unknown brand.

OBJECTIVES

Two specific objectives were sought in this experiment: the first was to evaluate the market qualities of market qualities of fryer-roaster turkeys grown from poults of large white varieties; the second, to evaluate the effectiveness of the various diet treatment combinations of specific fat and pigment supplements and/or additives fed during the experiment. The evaluation regarding these objectives was based on specific criteria of growth, finish, market quality, feed utilization, and consumer acceptance. The following hypotheses were developed and tested:

1. The performance of treatment groups receiving the basal rations regarding specified criteria will equal or excel that of birds receiving the other treatments.
2. The response of treatment groups receiving 3.0 percent added animal tallow regarding the specified criteria will excel that of the controls.
3. The response of treatment groups receiving 3.0 percent added animal tallow plus a surfactant will excel that of the control groups regarding specific criteria.

4. The response of groups receiving treatment diets containing 0 percent added animal fat will excel that of birds receiving the basal diet regarding the specified criteria.
5. The response of groups receiving the Florafil additive will excel that of birds fed the basal diet and equal or excel that of the groups receiving 10 percent corn gluten meal in the diet regarding pigmentation in the carcass fat and skin, as well as the specified criteria.
6. The response of groups receiving the treatment containing 10 percent of corn gluten meal will excel that of the control and equal or excel that of the Florafil treatments in pigmentation of carcass fat and skin, as well as the criteria specified.
7. Consumer preference panel members will express no preference between two samples of fryer-roaster turkeys differing approximately 1 pound in individual carcass weight.
8. Consumer preference panel members will express a definite preference for either the 6 pound or the 7 to 8 pound sample.
9. Consumer preference panel members will show no preference between the yellow pigmented sample and the sample exhibiting the natural white skin color.

10. Consumer preference panel members will express a definite preference for either the yellow pigmented sample or the sample having the natural white skin color.

MATERIALS AND METHODS

Trial 1

Procedure

A review of the literature revealed very little information in recent work related to growth and market quality with the popular commercial large white turkeys when they are grown for market at fryer-roaster weights. Thus, the decision was made to start the present project with feeding trials based on turkey starting and growing rations presently being recommended by the Poultry Extension Specialists, Michigan State University, using large white, female poults from a leading commercial breeder. Three diet treatments were used in this trial: Diet No. 1 was the basic turkey starting and growing feeding program; Diet No. 2 consisted of the basic diet but modified by the addition of 3 percent of stabilized animal tallow; and Diet No. 3 was the same as Diet No. 2 with a surfactant[1] added at the rate of 1 percent of the animal fat in the diet.

Eighty-two day-old Nicholas Large White female poults were received by parcel post at the Poultry Research Center

---

[1]Diethanol Amide, a tallow amide produced experimentally by Swift & Company, Union Stock Yards, Chicago 9, Illinois, and obtained through the courtesy of Dr. Keith Johnson.

Michigan State University, East Lansing, Michigan, on March 30, 1965. The poults were promptly wing-banded and started on feed and water in 8 sections of a starting battery. All poults were given the same 30 percent protein starting ration in mash form for the first 2 weeks. The birds were debeaked at 7 days of age by removing about one-fourth of the upper beak with a Lyons Electric debeaker. The intent was to remove only enough of the beak to prevent cannibalism before 12 weeks of age when the birds were to be slaughtered. At 2 weeks of age the poults were randomly distributed among 6 - 4 feet by 6 feet growing pens on ground corncob litter. Small 4-inch by 4-feet feeders were used for the first few days of brooding until the birds adjusted to eating from the larger hanging feeder. One hanging feeder was supplied in each pen. A 1-gallon, glass water fountain was used at the start and subsequently changed to a 3-gallon pan fountain with guard as the birds grew in size.

The protein content of the ration, which was 30 percent at the start of the trial, was adjusted down 2 percent at the end of each 2 week growing period until all the birds had been slaughtered; part at 11 weeks and the balance at 12 weeks of age.

All the poults were weighed at 6 weeks of age and 66 birds were selected from the 81 surviving poults to allow for six groups of birds consisting of 11 poults for each pen with a balanced distribution of sizes in each group. The weight of each bird was recorded when it was placed in the test pen. The test pens were numbered 1 through 6. The diet treatments were assigned to pens as follows: Diet No. 1 was fed to Pens 1 and 4; Diet No. 2 was fed to Pens 3 and 6; and Diet No. 3 was fed to Pens 2 and 5. The basic diets fed in each treatment are shown in Table 1. All treatments started when the birds were placed in the test pens at 6 weeks of age. The birds were weighed and the individual weights recorded at 2 week intervals from 6 weeks to 10 weeks of age. All the birds were weighed at 11 weeks of age, at which time the birds in Pens 1, 2 and 3 were slaughtered, eviscerated and ready-to-cook weights were recorded (giblets and necks included). Feed consumption records were obtained at each weighing period. The slaughtered birds were evaluated for finish and market quality by an expert panel of three men. The following week the remainder of the poults were weighed and slaughtered, graded and the eviscerated weights recorded in the same manner as were the turkeys from the first three pens.

Results of Trial 1

All of the turkeys, including the 11-week-old birds, were considered adequate in appearance to be graded "Grade A" turkey broilers. The panel observed no significant differences between the treatment groups at 11 weeks of age. Weight gains and feed conversion data for all pens are shown in Table 2. Analysis of variance of weight gains and feed conversion data failed to reveal any significant differences in the performance of the birds receiving the various treatments through 11 weeks of age for the 6 to 8 week, 8 to 10 week and 10 to 11 week growth periods. The panel evaluated the eviscerated carcasses of the birds from Pens 4, 5 and 6 (which were slaughtered at 12 weeks of age) to be approximately equal in appearance and found the fleshing and finish (fat in skin) markedly improved over that of the birds from replicate pens slaughtered at 11 weeks of age.

The birds were scalded at approximately 135° F. to facilitate the removal of pinfeathers. The removal of pinfeathers at this temperature presented no special problem for any of the treatment groups. The cuticle or epidermis of the skin was removed from the carcasses during the defeathering process at this temperature.

Only one bird was lost during the 6 week test period. This was a perotic bird which was in one of the pens receiving the surfactant and was removed at 10 weeks of age when it could no longer stand to reach feed and water. It was a male bird which had gotten into the trial through sexing error. This incidence may be of interest since Scott et al. (1952) noted the incidence of perosis in chicks fed surfactants. However, this seems unimportant as an isolated event in this trial.

TABLE 1.--Turkey starting and growing diets, Trial 1.

	(30%)	(28%)	(26%)	(24%)	(24%, 4 1/2%F)	(22%)	(22%, 4 1/2%F)	(20%)	(20%, 4 1/2%F)
Corn	39.50	44.25	48.61	53.43	49.82	58.16	54.55	62.99	59.37
Soybean Meal, Solvent-Dehulled (50%)	39.25	34.50	31.59	26.77	27.38	26.54	27.15	21.71	22.33
Fish Meal (60%)	5.00	5.00	3.75	3.75	3.75	2.50	2.50	2.50	2.50
Meat & Bone Scrap (50%)	5.00	5.00	5.00	5.00	5.00	2.50	2.50	2.50	2.50
Alfalfa Meal (17%)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Whey, Dried (12%)	2.00	2.00	1.50	1.50	1.50	1.00	1.00	1.00	1.00
Brewers Dried Yeast (45%)	1.00	1.00	1.00	1.00	1.00	.50	.50	.50	.50
Dist. Dried Sol., Corn (27%)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	.50	.50	.50	.50	.50	.50	.50	.50	.50
Dical. Phos., 26% Ca., 18% P.	1.50	1.50	1.75	1.75	1.75	2.10	2.10	2.10	2.10
Limestone (38% Ca.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NOPCOSOL M7 Vit. Min. Premix	.25	.25	.20	.20	.20	.20	.20	.20	.20
Tallow, stabilized	1.50	1.50	1.50	1.50	4.50	1.50	4.50	1.50	4.50
Calculated analysis:									
Protein	29.90	27.90	26.00	24.00	24.00	22.00	22.00	19.99	20.00
Calories per pound*	862	885	903	924	1017	983	1033	999	1050
Calorie-Protein Ratio	28.8	30.5	34.7	38.5	42.4	44.7	47	50	52.5

*Calculations allow 2900 Calories per pound for animal tallow.

TABLE 2.--Results of feeding trials from 6 to 11 weeks of age with large white female poults, Trial 1.

Diet No.	Pen No.	6 weeks	8 weeks		10 weeks		11 weeks	
		Av. wt.	Av. wt.	F/G[1]	Av. wt.	F/G	Av. wt.	F/G
1	1	1460	2460	2.29	3624	2.66	4003	4.50
1	4	1444	2410	2.31	3512	2.64	3925	4.15
1	Av.	1452	2435	2.30	3568	2.65	3964	4.32
2	3	1454	2398	2.27	3488	2.65	3929	3.88
2	6	1440	2402	2.27	3322	3.26	3830	3.29
2	Av.	1447	2400	2.27	3405	2.96	3880	3.58
3	2	1450	2456	2.11	3504	2.76	3945	3.38
3	5	1454	2431	2.37	3487	3.25	3917	4.42
3	Av.	1452	2444	2.24	3497	3.00	3931	3.90

[1]F/G indicates feed consumed per unit of gain in body weight.

Trial No. 2

Purpose

Since the results of Trial No. 1 failed to show any significant economic advantages to be derived from feeding large white female poults 3 percent added fat over the amount in the basal starting and growing ration, either with or without a surfactant, the decision was made to evaluate the performance of large white female poults of the same breeding as that used in Trial No. 1 when fed to light fryer-roaster weights on diets without added fat as compared with birds fed the basal diet. In addition, the performance of three levels of pigmenter were tested on the premise that yellow pigment in the skin and fat of immature turkey broilers might be perceived as a favorable quality factor by consumers. The two levels of fat and three levels of pigment were combined in a 2 x 3 factorial arrangement for statistical evaluation. (Consumer acceptance of pigmentation was evaluated in a third trial of this experiment in cooperation with the Agricultural Economics Department, Michigan State University.) The turkeys fed the six experimental diets were evaluated for market quality and finish, pigmentation, weight gains and feed conversion and the performances of the experimental groups were evaluated statistically for significance.

Procedure

One hundred fifty-four (154) Nicholas Large White female poults were delivered by Air Express from Swift and Co., Fresno, California, to the Poultry Research Farm, Michigan State University, East Lansing, Michigan, on August 12, 1965. The birds were promptly wing-banded and started on feed and water in 16 sections of starting batteries. All poults were fed the same 28 percent protein starting ration containing no added fat for the first 2 weeks. Except for the removal of the stabilized tallow, this ration was similar to the 28 percent protein diet fed in Trial 1. The birds were debeaked at 1 week of age; about one-fourth of the upper beak of each poult was removed with a Lyons Electric debeaker. At 10 days of age the poults were placed on the floor in twelve 4- x 6-feet pens. Aureomycin at 300 grams per ton, N. F.-180 at 4 pounds per ton and Amprol Plus at 0.0125 percent were added to the 28 percent starting ration when the birds were placed on corncob litter in the test pens. Only Amprol Plus was fed continuously in the ration for medication after the 14th day of brooding. All the diets were supplemented with an additional 20,000 IU of Vitamin E per pound of ration.

Four (4) electric heat lamps provided heat in each pen. Small feed troughs were used for a few days until the poults adjusted to eating from the larger hanging feeders. A 1-gallon water fountain was used at the start and then replaced with a 3-gallon pan fountain with guard.

At 14 days of age the poults were weighed and 132 were selected to provide 11 poults in each of the 12 floor pens with a balanced distribution of weight sizes in each pen. The pens were numbered 1 through 12. At this time the birds in six of the twelve pens were placed on a 28 percent protein starter with 1 1/2 percent added stabilized tallow while the rest of the birds continued on the 28 percent protein diet without added animal fat. The corn and soybean oil meal content of the ration was adjusted to allow for the addition of the fat without changing the protein content of the ration. The basic starting and growing diet recommended by the Michigan State University Poultry Extension Specialists was modified to provide the diets used in Trial No. 2. To provide no fat in this test, the fat was removed from the standard ration and the corn and soybean oil meal adjusted to provide the desired level of protein. Except for the addition of extra Vitamin E, the 1 1/2 percent fat level treatment ration was essentially the same as the basic diet used in Trial No. 1. All treatment diets fed during this experiment were calculated to contain the same protein level through each feeding period. A 28 percent protein diet was fed to 4 weeks of age after which the protein level was reduced to 24 percent for the period 4 to 8 weeks. A protein level of 20 percent was fed in all rations for the last 4 weeks until the birds were slaughtered at 12 weeks of age. The basic diets fed in this trial are shown in Table 3.

At 8 weeks of age the three pigment levels (no added pigment, Florafil and corn gluten meal) were added factorially to the two basic diets which contained no added fat (Diet A) and 1 1/2 percent added fat (Diet B). The treatment combinations were designated as follows: Diet A-1 contained no added fat or pigmenter; Diet A-2 contained Florafil but no added fat; Diet A-3 contained no added fat but 10 percent corn gluten meal (60 percent protein) was provided as a pigmenter; Diet B-1 contained 1 1/2 percent stabilized tallow but no pigmenter; Diet B-2 contained 1 1/2 percent tallow plus added Florafil to provide 10 milligrams of xanthophyll per pound of ration; and D-3 contained 1 1/2 percent added fat plus 10 percent corn gluten meal as the pigmenter.

The turkeys were weighed at 2 week intervals until they were slaughtered at 12 weeks of age. The total weight gain, average weight, feed consumed and feed conversion data were determined for each 2 week period. When the birds were slaughtered, one-half of the birds from each treatment pen were scalded at 130° F. and the remaining half of each pen were processed at 135° F. to assure samples of carcasses with and without the cuticle intact. The lower temperature allowed the cuticle to remain on the carcasses of the dressed birds while at the higher temperature the cuticle was completely removed in the defeathering process. (It was observed in Trial 1 that the carcasses of the turkey broilers exhibited yellow pigment in the skin only when the cuticle was intact.) The semi-scald (130° F.) thus assured yellow pigmented birds for consumer studies in Trial 3.

The dressed and eviscerated birds (roaster style) were weighed with giblets and necks included and the weights recorded for the individual birds. Dressing percentages were determined. The eviscerated carcasses were held in ice water overnight and then were displayed in their respective treatment groups identified only by code number. A panel evaluated the birds by treatment groups for pigmentation, finish, and market quality.

Results

The results of the feeding trials from 2 to 12 weeks of age for the six treatments tested for weight gain and feed utilization are given in Table 4. Analysis of variance of 10 week and 12 week body weights were highly significant ($P < 0.01$) for fat and pigment treatments. Analysis of variance of 4, 6 and 8 week body weights revealed no significant differences between the treatment groups. Significantly greater body weights were attained by the turkeys fed diets containing no added stabilized animal tallow at 10 and 12 weeks. Analysis of variance of carcass yield data revealed no significant differences between treatment groups. Regarding the pigment levels, the birds receiving treatments containing Florafil attained the greatest body weight average. The diets containing no pigment produced the second greatest weights while the treatments containing corn gluten meal produced the poorest growth. Both Florafil and no pigment treatments produced significantly ($P < 0.01$) greater body weights than the corn gluten meal diets at 12 weeks. However, at 10 weeks the Florafil treatments were significantly better than the corn gluten meal treatments for growth but not significantly different from the no added pigment treatments results. Analysis of variance Tables 5 and 7 show the comparison of average body weight data for the six treatments for the 10 and 12 week weighings. Analysis of variance of feed utilization data for the six treatments is shown in Table 9. The mean body weights by pen and treatment for the factorial combinations of fat and pigment levels at 10 and 12 weeks are shown in Tables 6 and 8, respectively.

Analysis of variance of feed utilization data for the periods 2 to 4, 4 to 6, 6 to 8 and 8 to 10 weeks for the six treatment groups failed to reveal any significant differences. However, significant differences ($P < 0.05$) in feed utilization were found for the fat and pigment treatments for the 10 to 12th week growing period. Among all treatment combinations, those containing no added pigment had the lowest ratio of feed per unit of weight gain, 3.13:1. The treatments containing corn gluten meal had the highest average feed conversion ratio, 3.49:1. The no-added-pigment treatments had a significantly lower average feed conversion ratio than the corn gluten meal treatments. However, the Florafil treatments were not significantly different from the other treatments regarding feed utilization at 10 weeks. Analysis of variance Table 9, shows feed conversion data for the six treatments from the 10th to 12th week. A comparison of these data for large white female poults by pen and treatment combinations is shown in Table 10.

TABLE 3.--Turkey starting and growing diets, Trial 2.

Ingredient	(28%)	(28% w/fat)	(24%)	(24% w/fat)	(20%)	(20% w/fat)	(20%)	(20% w/fat)
Corn	46.17	44.37	55.09	53.28	64.73	62.95	67.15	65.34
Soybean Oil Meal (50%)	34.54	34.83	26.56	26.87	21.42	21.70	9.00	9.31
Corn Gluten Meal (60%)	None	None	None	None	None	None	10.00	10.00
Fish Meal (57%)	5.00	5.00	3.75	3.75	2.50	2.50	2.50	2.50
Meat & Bone Scrap (50%)	5.00	5.00	5.00	5.00	2.50	2.50	2.50	2.50
Alfalfa Meal (17%)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Whey, Dried (12%)	2.00	2.00	1.50	1.50	1.00	1.00	1.00	1.00
Brewers Dried Yeast (45%)	1.00	1.00	1.00	1.00	.50	.50	.50	.50
Corn Dist. Dried Solubles (27%)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	.50	.50	.50	.50	.50	.50	.50	.50
Dical. Phos. (26% Ca., 18% P.)	1.00	1.00	1.75	1.75	2.10	2.10	2.10	2.10
Limestone (38% Ca.)	1.00	1.00	1.10	1.10	1.00	1.00	1.00	1.00
Nopcosol M-7 Vit-min Premix	.25	.25	.20	.20	.20	.20	.20	.20
Amprol Plus (0.0125 level)	.05	.05	.05	.05	.05	.05	.05	.05
Vit. E (20,000 IU/lb)	11.35 grams added per 100 pounds of ration in all rations							
Tallow, stabilized	None	1.50	None	1.50	None	1.50	None	1.50
Calculated analysis:								
Protein	27.999	27.996	24.00	24.005	20.000	19.999	19.999	19.999
Productive Energy (Calories)	918	943	941	966	975	1000	1020	1046
Calorie-Protein Ratio	32.8	33.7	39	40	49	50	51	52

TABLE 4.--Results of feeding trials for 2 week intervals from 2 to 12 weeks of age, Trial 2.

Age Diet No.	Pen No.	2 weeks Av. Wt. (gms.)	4 weeks Av. Wt. (gms.)	4 weeks F/G	6 weeks Av. Wt. (gms.)	6 weeks F/G	8 weeks Av. Wt. (gms.)	8 weeks F/G	10 weeks Av. Wt. (gms.)	10 weeks F/G	12 weeks Av. Wt. (gms.)	12 weeks F/G
A-1	1	254	726	1.62	1398	2.09	2402	2.30	3237	3.22	4313	3.33
A-1	8	254	690	1.68	1376	2.04	2329	2.30	3178	3.08	4245	3.19
A-1	Av.	254	708	1.65	1385	2.06	2365	2.30	3205	3.15	4277	3.26
A-2	2	257	713	1.63	1354	2.06	2354	2.22	3329	2.80	4291	3.57
A-2	9	257	725	1.65	1417	2.03	2391	2.25	3248	3.06	4334	3.25
A-2	Av.	257	719	1.65	1385	2.04	2372	2.23	3288	2.93	4313	3.41
A-3	3	257	720	1.65	1396	2.07	2339	2.40	3058	3.42	3878	3.77
A-3	7	256	706	1.65	1364	2.04	2304	2.28	2897	3.66	3889	3.59
A-3	Av.	256	713	1.65	1370	2.05	2321	2.34	2978	3.56	3883	3.68
B-1	4	254	690	1.73	1323	2.08	2281	2.34	3081	3.36	4012	2.97
B-1	11	254	684	1.61	1327	2.07	2301	2.22	2975	3.55	3964	3.03
B-1	Av.	254	687	1.67	1325	2.07	2291	2.28	3028	3.45	3988	3.00
B-2	5	256	693	1.58	1337	2.00	2204	2.28	3034	2.96	3963	3.48
B-2	12	256	701	1.63	1394	2.02	2404	2.23	3096	3.59	4214	3.23
B-2	Av.	256	697	1.60	1365	2.01	2304	2.25	3064	3.27	4086	3.35
B-3	6	252	694	1.61	1327	2.14	2238	2.24	2890	3.32	3749	3.12
B-3	10	255	695	1.62	1342	2.08	2297	2.20	2908	4.00	3685	3.47
B-3	Av.	254	694	1.61	1338	2.11	2267	2.22	2899	3.66	3717	3.27

TABLE 5.--Analysis of variance of 10 week body weights.

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Fat	1	418,133	418,133	7.50**
Pigment	2	1,600,890	800,445	14.36**
Interaction	2	18,434	9,217	.14
Subtotal	5	2,027,457	405,491	7.27**
Error	102	5,687,045	55,755	
Total	107	1,050,308,850		

**Significant at the 0.01 level of probability.

TABLE 6.--Comparison of average body weight data for 10 week old large white female poults by pen and treatment combinations.

Fat Levels	Treatments: Pigment Levels: No Added Pigment, Pen No.	No Added Pigment, Mean (gms.)	Florafil, Pen No.	Florafil, Mean (gms.)	Corn Gluten Meal, Pen No.	Corn Gluten Meal, Mean (gms.)	Fat Level Means (gms.)
No added fat	1	3231.1	2	3356.6	3	3037.2	
	8	3172.2	9	3263.8	7	2954.4	
	Av.	3201.7	Av.	3310.3	Av.	2995.8	3169.3**
Added fat (1 1/2%)	4	3055.0	5	3052.7	6	2900.0	
	11	3081.1	12	3287.7	10	2892.2	
	Av.	3068.0	Av.	3170.3	Av.	2896.1	3044.8
Difference between means of fat levels		133.7		139.9		99.7	124.5
Pigment treatment means**		3135.0 (a)		3240.2 (a)		2946.0 (b)	3092.0

**Means with common letters, e.g., (a) (b), are not significantly different ($P < 0.01$) when compared by Duncan Multiple Range test.

TABLE 7.--Analysis of variance of 12 week body weights.

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Fat	1	1,172,916	1,172,916.0	12.68**
Pigment	2	3,507,973	1,753,986.5	18.96**
Interaction	2	73,949	36,974.5	.40
Subtotal	5	4,754,808	950,961.6	10.28**
Error	102	9,435,117	92,501.1	
Total	107	14,189,925		

**Significant at the 0.01 level of probability.

TABLE 8.--Comparison of average body weight data for 12 week old large white female poults by pen and treatment combinations.

Fat Levels	Treatments: Pigment Levels: No Added Pigment, Pen No.	No Added Pigment, Mean (gms.)	Florafil, Pen No.	Florafil, Mean (gms.)	Corn Gluten Meal, Pen No.	Corn Gluten Meal, Mean (gms.)	Fat Level Means (gms.)
No added fat	1	4309.4	2	4307.2	3	3832.0	
	8	4185.5	9	4345.0	7	3876.6	
	Av.	4247.5	Av.	4326.1	Av.	3854.4	4142.6
Added fat (1 1/2%)	4	4012.2	5	3962.7	6	3783.8	
	11	4003.8	12	4187.2	10	3655.5	
	Av.	4008.0	Av.	4075.0	Av.	3719.7	3934.2
Difference between means of fat levels		239.5		247.2		134.7	208.4
Pigment Treatment means*		4127.7^{a}		4200.5^{a}		3787.4^{b}	4038.4

*Means with common letters, e.g., (a) (b), are not significantly different ($P < 0.01$) when compared by Duncan Multiple Range test.

TABLE 9.--Analysis of variance of feed conversion data for 10 to 12 week period.

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Fat	1	0.164	0.164	8.63*
Pigment	2	0.270	0.135	7.11*
Interaction	2	0.113	0.0565	2.97
Subtotal	5	0.547	0.1094	5.76*
Error	6	0.114	0.019	
Total	11	133.994		

*Significant at the 0.05 level of probability.

TABLE 10.--Comparison of average feed conversion data for 10 to 12 week growth period for large white female poults by pen and treatment combinations.

Fat Levels	Treatments: Pigment Levels: No Added Pigment		Florafil		Corn Gluten Meal		Feed Conversion
	Pen No.	F/G	Pen No.	F/G	Pen No.	F/G	
No added fat	1	3.33	2	3.57	3	3.77	
	8	3.19	9	3.25	7	3.59	
	Av.	3.26	Av.	3.41	Av.	3.68	3.45
Added fat (1 1/2%)	4	2.97	5	3.48	6	3.12	
	11	3.03	12	3.23	10	3.47	
	Av.	3.00	Av.	3.36	Av.	3.30	3.22
Difference between fat level conversion data		.26		.05		.38	
Pigment level conversion ratio mean*		3.13^{a}		3.38^{ab}		3.49^{b}	

*Means with common letters, e.g., (a) (b), are not significantly different ($P < 0.05$) when compared by Duncan Multiple Range test.

Quality Evaluation

The treatment groups were evaluated for pigmentation, finish and conformation by capable judges. The pigmentation evaluation was concerned with the development of yellow pigment in the skin of the turkeys. Finish was determined by the degree and extent of coverage of fat in the skin. Conformation included the degree of development, shape and fleshing of the birds. The market grade (anonymous, 1964b), "Grade A," was assigned to all of the treatment groups. However, the panel observed notable differences between certain treatment groups in pigmentation, finish and conformation. The turkeys fed Diet A-3, which contained 10 percent corn gluten meal with no added fat, were rated highest in pigmentation and finish. The birds fed Diet A-2, containing Florafil as an added pigmenter, were rated second in color and finish. Among the treatment groups fed no added fat, Diet A-1 produced the poorest conformation.

Among the treatments containing added fat, birds on Diet B-3, containing 10 percent corn gluten meal, were rated highest in pigmentation and finish. Turkeys on Diet B-1, which contained no pigmenter, were rated highest for conformation. Diet B-1 and Diet B-2 produced birds that were rated equal for pigmentation and finish.

The panel found no differences in skin pigmentation between the various treatment groups when the cuticle was removed. The diets containing corn gluten meal gave the best pigmentation as observed in the skin color only when the cuticle was intact on the dressed bird. Although superior pigmentation was observed in the abdominal fat of the birds fed rations containing 10 percent corn gluten meal, it appears that the intensity of pigmentation or, perhaps, the deposition of fat in the skin of 12-week-old turkeys is not adequate to show pigmentation after the cuticle is removed.

The pigmenter, Florafil, at 4 pounds per ton, was rated equal to the treatments to which no extra pigmenter was added. However, the Florafil seemed to enhance feed consumption and weight gains. Though the treatments containing Florafil produced the largest average weights among the treatment groups, these weights were significantly different only from that of the treatments containing corn gluten meal. Birds on Florafil containing treatments were not significantly different from those on treatments containing no added pigment.

Consumer Evaluation Panel Test

According to Greig, as found in Sorenson (1964), a firm within the food industry strives to exploit existing demand for its products and to create new demand. It can do this in two ways: (1) it can alter consumers' attitudes and beliefs concerning the product by advertising and promotion or (2) it can change the quality of the product to more closely conform to consumers' current preferences and prejudices. Quality is defined in this case to include color, shape, materials, design, grade, service and other qualitative characteristics perceived to be important by consumers. Regardless of the method employed to exploit existing demand for a product, a firm must continually try to obtain better knowledge of consumers' activities, habits, tastes, wants and customs. If useful information is obtained, the firm can then change the product and the product quality experimentally to test new ideas concerning consumer wants and actively search for innovations with the same end in mind.

In this trial, the attempt was made to determine the influence of the quality factors: (1) size of carcass and (2) degree of pigmentation on consumer acceptance of fryer-roaster (broilers) turkeys grown from large type white female poults.

Procedure

Samples were selected for uniformity of size, body conformation, and pigmentation. Three birds were selected from those processed at 11 weeks of age in Trial 1. The birds weighed approximately 6 pounds each, ready-to-cook. Another sample of three birds weighing 7 to 8 pounds was selected from the turkeys processed at 12 weeks of age. The birds in both samples were processed and prepared for display by similar procedures. All were packed in heat shrinkable plastic bags and frozen at -40° F. to assure a relatively white appearing skin as is the practice in commercial plants.

Two samples of three birds each were selected from those processed at 12 weeks of age in Trial 2 for the evaluation of pigmentation as a consumer quality factor. One sample was selected from those birds dressed at 130° F. and exhibiting marked yellow pigment in the carcass skin. The other sample was selected from the birds dressed with the scalding water at a temperature of 135° F. and from which the yellow cuticle had been completely removed. This sample was selected to be equal in size and conformation to the pigmented sample but exhibiting the typical white turkey carcass skin color.

The symbols "(), *, & and %," which suggest no implied order, were used to designate the different samples. The two comparison tests were designated as I and II. As noted by Marquardt (1964), a comparison test is a method whereby the panelist judges paired samples by comparing one sample with the remaining samples. The panelist selects the sample he prefers and indicates his preference by placing 1 by the symbol which identifies the sample he prefers and 2 by the other sample. The two samples compared in Test I were designated by "%" and "&". The "%" symbol represented the relatively light weight, eviscerated, ready-to-cook turkey roasters weighing approximately 6 pounds each and "&" represented birds weighing 7 to 8 pounds, similarly prepared as were the lighter birds.

The second comparison test, designated as Test II, consisted of two samples of three birds each. In this test, the symbol "()" represented ready-to-cook carcasses of 12-week-old fryer roaster turkeys grown out of large white, female poults but fed and processed so that the birds exhibited a deep yellow pigment in the skin. The second sample was represented by the symbol "*" and was similar to the "()" sample except that the birds were produced and processed to exhibit the more common natural white appearance of turkeys.

Consumer preference panels in Detroit, Michigan, composed of a cross section of income levels and representing approximately 79 percent of the gross income of residents of that city, were used throughout the tests reported in this study.

The binomial test (sign test) was selected to evaluate the experimental results. Analysis of the data required that plus and minus signs be used for the 1 and 2 placings, respectively, that were used by the panel members. Thus, the placing by each panel member can be viewed as a "success" or "failure" or more preferably, in this study, as "accept" or "reject" according to the interpretation we place on a 1 (plus) or 2 (minus) rating by each panel member.

Panel Instruction and Procedure

Members of the consumer evaluation panel ranked several different types of products at each panel meeting. Immediately prior to each panel session, groups of 10 to 20 members were given instructions concerning the different series of items to be ranked and the forms on which to rank each series of products. A new group was briefed every half hour. The products were displayed on tables in a large room and from 10 to 20 panelists at a time proceeded independently to rank the samples. When an individual member completed his ranking of the products, his forms were checked to make sure that he had ranked all the products within each series.

The members were not told the purpose of the specific test. They were told only that the samples were to be ranked according to their individual preferences. The respondents were allowed to express preference for or against either or both samples without regard to price. Voluntary written comments were permitted.

Results of Paired Comparison Tests

The comparison tests were conducted during an afternoon and an evening session on the same day. A total of 60 consumers completed acceptable consumer evaluation cards for the two tests during the afternoon session. A sample evaluation card is shown in Figure 1. Regarding comparison Number I, the test of small fryer-roasters (6 pounds) versus heavier fryer-roasters (7 to 8 pounds), the choices were evenly divided: 30 panel members preferred the smaller birds to 30 who preferred the larger carcasses. Consumer preference data for Test I and Test II are shown in Tables 11 and 12. Table 11 presents the data as taken from the panel members' forms and Table 12 shows the data adopted for the sign test. The results were similar during the evening session for comparison Number I with 43 panelists placing "1" beside the smaller birds, 52 placing a "2" beside the smaller birds and 1 panelist indicating no choice. A total of 54 panel members placed "1" beside the larger birds, 41 placed a "2) beside the larger birds and 1 panel member indicated no choice. It is apparent here that 2 panelists voted favorably for both the small and large birds so the data were adjusted by removing these two votes to meet the requirements of the binomial test. Though the division of preferences is not exactly even in this, the difference is so small that it could have easily happened by chance and is not significantly different. The statistical analysis procedure used was the binomial test.

In comparison Number II, the comparison of pigmented birds versus naturally white birds, consumer preferences were decidedly in favor of the naturally white birds in both the afternoon and evening sessions as can be seen in Table 11. A total of 18 panelists rated the yellow pigmented birds as "1" indicating

TABLE 11.--Consumer preference as influenced by carcass size and pigment in skin of ready-to-cook fryer-roaster turkeys.

Comparison Test No. and Sample Symbol:	Consumer Evaluation Session					
	Afternoon			Evening		
	1[1]	2	X	1	2	X
Test I						
%	30	30	0	43	52	1
&	30	30	0	54	41	1
Test II						
()	18	42	0	23	72	1
*	44	16	0	72	23	1

[1] 1 = Accepted
2 = Rejected
X = Indicated no preference or an omission.

TABLE 12.--Consumer preference data adapted for analysis by binominal test.

Comparison Test No. and Sample Symbol:	Consumer Evaluation Session							
	Afternoon[1]				Evening[1]			
	+		-		+		-	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Test I								
%	30	50	30	50	41	44.07	52	55.93
&	30	50	30	50	52	55.93	41	44.07
Total	60	100	60	100	93	100.00	93	100.00
Test II								
()	16	27.59	52	72.41	23	24.21	72	75.79
*	42	72.41	16	27.59	72	75.79	23	24.21
Total	58	100.00	58	100.00	95	100.00	95	100.00

[1]+ = Accepted
\- = Rejected

Number______

MICHIGAN STATE UNIVERSITY

<u>Turkey</u>

I.	II.
%________	()________
&________	*________

Name__________________________________ Comments__________________________________

Figure 1.--Form for Consumer Evaluation Test.

preference for the yellow carcasses over the white. A total of 44 out of the 60 panel members rated the yellow birds "2" indicating disfavor. A total of 44 panelists rated the white birds as "1" while 16 rated the sample as "2". It can be seen that two panel members rated both the yellow pigmented birds and the naturally white birds as "1" or favorable. The choices of these two panelists were dropped from the data as shown in Table 12 as required for the binomial test. The data thus corrected shows 16 panelists rating the yellow pigmented birds as "1" and 42 rating them as "2" while 42 members rated the white skinned birds "1" and 16 rated them "2". From the proportions it may be interpreted that 27.59 percent of the panel members favored the yellow carcasses while 72.41 percent of the panelists rejected them. There was a highly significant difference in favor of preference for the white birds (Probability of Type I Error < 0.01).

During the evening session, 95 panel members completed acceptable consumer evaluation cards. A total of 23 of these panelists rated the yellow pigmented turkeys as "1", while 72 rated them as "2". A total of 72 panelists out of 95 rated the white birds "1", while 23 rated them "2". Each panelist expressed a distinct preference for one sample over the other. The proportion of panel members favoring the pigmented birds was 24.21 percent while 75.59 percent of the members rejected them and expressed preference for the white birds. These results are highly significant ($P < 0.01$). The difference in favor of the white birds was expressed in both the afternoon and evening session and was significant whether the results of each session were evaluated individually or combined. However, the proportions of panelists accepting the white birds in the afternoon and evening sessions were significantly different at the 0.05 level. This difference may be due to chance differences of opinion between the two population samples or to changes in the appearance of the samples resulting from thawing and exposure to the air during the panel evaluation sessions.

Conclusions

It appears from the information obtained in this study that a difference in weight of approximately 1 pound between two samples of turkey broilers is not important in influencing preference for one sample over the other. The fact that the smaller birds were only 11-weeks-old, and thus lacked in appearance as compared to the heavier sample, failed to influence the choices of the panel members. The panelists appeared to have no difficulty in perceiving that a size and wieght difference existed between the samples in Comparison Test I. Typical comments of panel members viewing this sample are as follows: "I like the small ones so I can have them once and that's the end of it." "I like the larger turkeys; my family will tolerate turkey three times without complaint." "These appeal to me for my family because they are small." "I like them big." "I'd never buy a turkey with pinfeathers because if they are careless about that, they are probably careless how they cleaned the birds and the rest."

These data indicate that the natural white color of turkey fryer-roasters is preferred by a significant majority of the population sampled. The study does not attempt to determine why the majority of the panelists preferred the white birds but comments of panel members during the study indicated that some individuals associated the yellow color with fatness which caused them to discriminate against the yellow birds. They believed the meat from such birds would be more fattening than meat from the white birds. Several panelists perceived the yellow pigmentation as green and associated this with spoilage.

The yellow pigmented birds, with the cuticle or epidermis intact, lacked the smooth texture of skin that was exhibited in the white birds from which the yellow cuticle had been completely removed. The resulting coarser skin texture of the yellow birds was perceived as an undesirable factor by same panelists. This roughness of skin could be eliminated in subsequent tests by using clear and pigmented shrinkable bags. This would permit processing of the test birds so both samples would exhibit the same skin texture.

Typical comments made by panelists viewing Comparison Test Number II are as follows: "The pigmented birds look older." "Don't these (yellow pigmented sample) look kind of green? They're too blotchy and rough looking --must have been sick." "These yellow birds look older. The other birds look fresher." "I think the yellow birds would be fatter. The pinkish ones would be too dry." "These (pigmented) have got more fat; the others are leaner."

Based on the findings of this study, the following generalizations regarding the production and processing of fryer-roaster turkeys to comply with consumer preferences are offered:

Turkey fryer-roasters slaughtered and processed ready-to-cook at weights ranging from 6 to 8 pounds per carcass will be accepted by consumers without important size preference differences.

Turkey fryer-roasters produced from large white type female poults may be marketed at 11 weeks of age as readily as at 12 weeks of age regarding consumer preference for finish and conformation.

The present system of feeding and processing turkey fryer-roasters to exhibit a white skin color is preferred to feeding and processing procedures that would result in a dark yellow pigmented skin.

This study did not evaluate consumer preference for a lighter shade of yellow pigment in the skin of the carcass or the carcass package as would be the case with differently colored shrinkable bags. It seems that further studies evaluating varied degrees of pigmentation would be desirable. Variation in skin texture should be avoided as an uncontrolled variable in future studies.

DISCUSSION AND SUMMARY

A review of the literature revealed that various ideas have been offered by researchers as a result of their interpretations of research results regarding the use of feedstuffs, feed additives and hormone injections or implants to enhance the rate of growth, feathering, finish and feed efficiency of chickens and turkeys. The oral feeding and subcutaneous implantation or injection of hormone or hormone-like compounds with chickens and turkeys have produced variable results but have generally improved the finish of the bird. The use of added dietary fat to increase the energy content and nutrient density of poultry and turkey rations has generally resulted in diets that improved feed conversion, gain, and, sometimes, finish. The idea of specific inherent benefits being associated with the feeding of fats as put forth by Donaldson et al. (1956) is questioned somewhat by the findings of Baldini et al. (1955; 1957) that growth, feed conversion and body composition were not changed by increasing the fat content of the diet when the Calorie value of the diet was held constant. The use of surface active agents in chicken and turkey diets has resulted in improved and negligible responses in growth. The surfactant used in this study failed to enhance growth, feed conversion or deposition of skin fat in turkeys. The idea that maximum growth, feed utilization and finish may be obtained by compounding rations with certain ratios of units of energy per unit of protein has been generally supported by the research cited though fairly conclusive evidence is also reported to show that improved amino acid balance in the protein fraction of the diet will reduce the level of total protein needed in relation to the energy of the diet. Added fat in Trial 1 failed to improve growth, finish and feed utilization over the basal diet.

The results from Trial 2 of this experiment show that while added dietary fat and the related added energy significantly improved feed utilization, growth was significantly impaired as compared to the response of turkey poults fed diets containing no added fat. The fact that feed utilization results were significantly different in favor of added animal fat only during the 10 to 12 week feeding period suggests that poults may not be able to completely utilize this fat to 10 weeks of age.

The failure of turkeys in the treatment groups in Trial 2 to respond favorably to the added stabilized tallow may have occurred because relatively low protein levels were used in the treatment rations without supplementation with added lysine and methionine. The Calorie: protein ratios (Table 4) used in this trial between 8 to

12 weeks of age, were 8 to 10 units wider than the ratios recommended for commercial feeding. According to Couch (1966), a 27-30:1 ratio is recommended for poults to 5 or 8 weeks of age and a 42:1 ratio for the 9 to 12 week period.

It appears that the supplementing of turkey starting and growing diets to 12 weeks of age with 1 1/2 percent of animal tallow and of growing diets with 4 1/2 percent animal tallow, with and without a surfactant, failed to produce improved finish and conformation over similar diets containing no added fat.

The supplementing of turkey growing diets with Florafil, a xanthophyll supplement, yielded superior growth over diets containing 10 percent corn gluten meal as a pigmenter, but was not significantly different from the response of poults fed diets containing no added pigment. Although the birds fed the diets containing Florafil were rated fairly high for finish by the panel, the fact that the degree of pigmentation in the fat of these birds was not observably different from that of birds fed diets containing no added pigmenter suggests that the favorable appearance of the Florafil fed birds was the result of excellent general growth and not a specific response to the added pigment.

The diets containing 10 percent corn gluten meal produced the best observable pigmentation when the cuticle remained an intact part of the skin of the dressed turkey carcasses. However, there were no differences in pigmentation between the various treatment groups when the cuticle was removed from the test birds in the defeathering process.

The significantly poorer growth response of the birds fed the diets containing 10 percent corn gluten meal was probably due to an amino acid imbalance which resulted from the replacing of part of the soybean oil meal, a relatively high source of lysine, with the corn gluten meal, a low source of this important amino acid.

This experiment was limited to the treatments tested because of limited time, facilities, and other resources. Studies regarding certain economic aspects of the research results might be in order, but were not included in this study for the reason stated above. Further studies regarding fat supplementation combined with higher levels of protein or selected levels of certain essential amino acids would seem to offer worthwhile possibilities regarding early finish and growth development. Consumer preference studies with different populations regarding a wider range of carcass weights and varied degrees of pigmentation would seem desirable. Such studies should preceed further efforts to develop high levels of pigmentation in the fat and skin of fryer-roaster turkeys. Studies should be continued toward the development of finish at an early age in turkeys.

Hypothesis 1 which predicted equal or superior performance of birds fed the basal diet is accepted and hypotheses 2 and 3 which predicted superior performance of treatment groups fed supplemental animal fat and fat plus a surfactant, respectively, are rejected. Hypothesis 4 which predicted superior performance of turkeys fed 0 supplemental fat is accepted. Hypothesis 5 is rejected, the prediction that the groups receiving Florafil would excel in pigmentation was disproved. Hypothesis 6 is accepted under the condition that the cuticle or epidermis remains intact on the processed carcass; it is rejected when the cuticle is completely removed. Hypothesis 7 which predicted no preference between fryer-roaster samples differing approximately 1 pound in weight is accepted. Hypothesis 8 which predicted a definite preference for one sample size over the other is rejected. Hypothesis 9 which predicted no preference on the part of the panel members between the pigmented and unpigmented samples is rejected. Hypothesis 10 which stated that panel members would express a definite preference for either the yellow pigmented sample or the sample with the natural white skin color is accepted.

REFERENCES

Adams, J. L. 1956. The effect of diethylstilbestrol on large type *versus* small type turkey broilers. Poultry Sci. 35:1251-1254.

Adams, J. L. 1957. A comparison of methods of administering estrogenic hormones on growth, fattening and feed efficiency in B. B. Bronze turkeys. Poultry Sci. 36:1101.

Aitkin, J. R., G. S. Lindblad and W. G. Hunsaker. 1954. Beef tallow as a source of energy in broiler rations. Poultry Sci. 33:1038.

Almquist, H. J. and J. B. Merritt. 1952. Effect of diethylstilbestrol on gains and feed conversion of turkeys. Poultry Sci. 31:749.

Almquist, H. J. & J. B. Merritt. 1955. The effects of a detergent in the diet of range turkeys. Poultry Sci. 34:740.

Anonymous. 1964a. Poultry and Egg Situation, U. S. D. A., May 1964, p. 9.

Anonymous. 1964b. Regulations Governing the Grading and Inspection of Poultry and Edible Parts Thereof and United States Classes, Standards, and Grades with Respect Thereto, U. S. D. A., July 1964.

Anonymous. 1966. Supplement to the Poultry and Egg Situation, May 1966.

Anson, M. L. 1939. The denaturation of protein by detergents and bile salts. Science 90:256-257.

Atkinson, R. L., A. A. Kurnick, T. M. Ferguson, B. L. Reid, J. H. Quisenberry and J. R. Couch. 1957. Protein and energy levels for turkey starting diets. Poultry Sci. 36:767-773.

Baldini, J. T., H. R. Rosenberg and J. Waddell. 1954. The protein requirements of the turkey poult. Poultry Sci. 33:539-543.

Baldini, J. T. and H. R. Rosenberg. 1955. The effect of productive energy level of the diet on the methionine requirement of the chick. Poultry Sci. 34:

Baldini, J. T. and H. R. Rosenberg. 1957. The effect of Calorie source in a chick diet on growth, feed utilization and body composition. Poultry Sci. 36:1031-1035.

Baylock, L. G., J. R. Hunt, F. Ziegler, E. B. Patterson and W. J. Stadelman. 1954. The effect of energy level of the diet on growth, feed efficiency and degree of fattening of turkeys. Poultry Sci. 33:864-866.

Biely, J., B. E. March and D. A. Silverstrini. 1954. Fat studies in poultry. I. Herring oil, Santomerse --80 and thyroprotein in the laying ration. Poultry Sci. 33:1130-1135.

Biely, J. and B. March. 1954. Fat studies in poultry. II. Fat supplements in chick and poult rations. Poultry Sci. 33:1220-1227.

Bird, H. R., S. J. Marsden and W. L. Kellogg. 1948. Supplements for soybean meal in turkey diets. Poultry Sci. 27:53-59.

Carter, R. D., J. W. Wyne and H. Yacowitz. 1957. Effect of dietary energy and protein level on growth and feed conversion of turkeys from 8 to 16 weeks of age. Poultry Sci. 36:824-828.

Carter, R. D., J. W. Wyne, V. D. Chamberlin and M. G. McCartney. 1958. Oral administration of estrogens and their effect of growth, feed conversion and carcass quality of growing turkeys. Poultry Sci. 37:1284-1288.

Carter, R. D. and J. W. Wyne. 1956. The relation between protein and energy levels in finishing rations for turkey broilers. Poultry Sci. 35:1136.

Carver, D. S. 1959. Variation in the effects of fat supplements on broiler pigmentation, growth and feed conversion. Poultry Sci. 38:71-76.

Carver, D. S., E. E. Rise, R. E. Gray and P. E. More. 1955. The utilization of fats of different melting points added to broiler feed. Poultry Sci. 35: 544-546.

Combs, G. F., N. V. Helbacka and G. L. Romoser. 1958. Effect of diethylstilbestrol, pelleting, dietary fat level and Calorie-protein ratio on growth, feed requirements and quality of turkey fryers. Poultry Sci. 37:855.

Couch, J. R. 1965. Turkey nutrition--1966. Feed Age 15(12):26-29.

Creiger, C. R., R. H. Mitchell, M. L. Jones, R. L. Atkinson, J. H. Quisenberry and J. R. Couch. 1960. The effect of oral administration of diethylstilbestrol and dienestrol and dienestrol diacetate on growth rate and efficiency of feed utilization of Beltsville Small White turkey broilers. Poultry Sci. 39:1041-1045.

Cullen, M. P., O. G. Rasmussen and O. H. M. Wilder. 1962. Metabolizable energy values and utilization of different types and grades of fat by the chicken. Poultry Sci. 41:360.

Culton, T. G. and H. R. Bird. 1941. The effect of certain protein supplements in inhibiting pigment deposition in chickens. Poultry Sci. 20:432-436.

Davidson, J. A., L. F. Wolternik and E. P. Reineke. 1944. Some effects of high dosages of synthetic estrogens in young turkeys. Poultry Sci. 25:400.

Day, E. J. and W. P. Williams, Jr. 1958. A study of certain factors that influence pigmentation in broilers. Poultry Sci. 37:1373-1381.

Donaldson, W. E., G. F. Combs and G. L. Romoser. 1956. Studies on energy levels in poultry rations. I. The effect of Calorie-protein ratio on growth, nutrient utilization and body composition of chicks. Poultry Sci. 35:1100-1105.

Duncan, D. B. 1955. Multiple Range and F Tests. Biometrics 11(1):1-42.

Dunkelgod, K. E., E. W. Gleaves, L. V. Tonkinson, R. H. Thayer and J. J. Sirny. 1961. Daily nutrient intake as a basis for formulating turkey starter and grower diets. Poultry Sci. 40:1086-1097.

Dymsza, H., R. V. Boucher and M. G. McCartney. 1953. Response of growing turkeys to variations in the fiber and energy content of mash and pelleted diets. Poultry Sci. 38:898.

Dymsza, H., R. V. Boucher and M. G. McCartney, 1955. The influence of fiber content and physical form of the diet on the energy requirements of turkeys. I. Studies with turkey poults. Poultry Sci. 34:435-439.

Ely, C. M. 1951. Chick growth stimulation produced by surfactants. Science 114:523-524.

Ely, C. M. and S. Schott. 1952. Surface active agents as growth stimulators in chick rations. Proc. of Seventh Distillers Feed Conf., Cincinnati, Ohio, pp. 72-84.

Ferguson, T. M., H. P. Vaught, B. L. Reid and J. R. Couch. 1956a. The effect of amino acid supplements to the diet of Broad Breasted Bronze turkey poults fed various levels of protein and productive energy. Poultry Sci. 35:1069-1073.

Ferguson, T. M., H. P. Vaught, B. L. Reid and J. R. Couch. 1956b. Growth of Broad Breasted Bronze turkey poults fed a 26 percent protein diet with different levels of productive energy. Poultry Sci. 35: 1305-1308.

Flett, L. 1942. Detergents from petroleum. Chem. and Eng. News 20(13):844-848.

Fritz, J. C., F. D. Wharton, Jr. and L. J. Classen. 1957. Influence of feed on broiler pigmentation. Feedstuffs 29:18.

Harms, R. H., J. H. Quisenberry and J. R. Couch. 1958. The effects on broiler pigmentation of incorporating milo, dehydrated alfalfa meal and diphenyl-p-phenylenediamine (DPPD) in the diet. Poultry Sci. 37:143-147.

Harris, R. S., H. Sherman and W. W. Ketter. 1951. Nutritional and pathological effects of sorbitan monolaurate, polyoxethylene sorbitan monolaurate, polyoxyethylene monolaurate and polyoxyethylene monostearate when fed to rats. Arch. Biochem. Biophys. 34:249-258.

Hammond, J. C. and H. M. Harshaw. 1941. Some factors influencing shank and skin color in the growing chicken. Poultry Sci. 20:437-444.

Heiman, V. and L. W. Tighe. 1943. Observations on the shank pigmentation of chicks. Poultry Sci. 22: 102-107.

Hill, F. W. and L. M. Dansky. 1950. Studies on the protein requirements of chicks and its relation to dietary energy level. Poultry Sci. 29:763.

Hill, F. W. and L. M. Dansky. 1951. The influence of diet on body composition of growing chicks. Proc. Cornell Nutr. Conf. pp. 27-32.

Hill, F. W. and L. M. Dansky. 1954. Studies on the energy requirements of chickens. I. The effect of dietary energy level on growth and feed consumption. Poultry Sci. 33:112-119.

House, W. B. 1957. Carcass and shank pigmentation. Feedstuffs 29-31.

Japp, R. G. and R. H. Thayer. 1944. Oral administration of estrogens in poultry. Poultry Sci. 23:249-251.

Japp, R, G. 1945. Activity of synthetic estrogens on oral administration in the domestic fowl and turkey. Endocrinology 37:369-376.

Lane, R. P., J. H. Quisenberry, J. R. Couch and S. O. Brown. 1951. Effects of feeding poultry certain hormones on growth and market quality of poultry; results of biochemical tests for hormonal residue. Poultry Sci. 30:921.

Leucke, R. W., J. A. Hoefer and F. Thorp. 1952. Growth stimulating effect of a surface active agent on pigs. Michigan State College Agr. Exp. Sta. Bull. 34(3):331-332.

Lockhart, W. C. and R. H. Thayer. 1955. Energy-protein relationships in turkey poult starters. Poultry Sci. 34:1208.

Lorenz, F. W. 1944. The influence of diethylstilbestrol on fat deposition in turkeys. Poultry Sci. 23: 458-459.

Lorenz, F. W. 1945. The influence of diethylstilbestrol on fat deposition and meat quality in chickens. Poultry Sci. 24:128-134.

Makens, J. C. 1960. An evaluation of mandatory grade and sex labeling of turkeys. Unpublished thesis for the degree of M. S., Michigan State University.

Makens, J. C. 1963. The influence of brands upon consumer preference for frozen whole turkeys. Unpublished thesis for the degree of Ph. D., Michigan State University.

Marquardt, R. A. 1964. An evaluation of the methods used in designing and analyzing consumer preference studies. Unpublished thesis for the degree of Ph.D., Michigan State University.

Maw, W. A. 1939. Cereals in the poultry ration. Seventh World's Poultry Congr. Proc. pp. 177-178.

McCartney, M. G. 1952. Rate of growth, efficiency of feed utilization and market quality in three varieties of turkeys to eighteen weeks. Poultry Sci. 31:838-843.

Mills, W. C., Jr., L. E. Dawson and H. E. Larzelere. 1961. A study of word versus letter grading of turkeys. Poultry Sci. 40:537-542.

Miner, J. J., S. J. Marsden and C. A. Denton. 1959. The effect of diethylstilbestrol-methimazole and dienestrol diacetate on turkey broilers. Poultry Sci. 38:750-757.

National Research Council. 1954. Nutrient requirements for domestic animals. I. Nutrient requirements for poultry. Pub. 301.

Neidig, C. P. and A. B. Hersberger. 1952. Organic synthetic detergents. Chem. and Eng. News 30(35):3610-3615.

Ostle, B. 1963. Statistics In Research, 2nd Ed., The Iowa State University Press, Ames, Iowa.

Palmer, L. S. 1915. Xanthophyll, the principal natural yellow pigment of the egg yolk, body fat and blood serum of the hen. The physiological relationship of the pigments to the xanthophylls of plants. J. Biol. Chem. 23:261-279.

Potter, L. M., L. D. Matterson, D. Carlson and E. P. Singsen. 1956. Studies on the effect of varying protein levels and Calorie-protein ratios in poultry rations on growth and feed efficiency. Poultry Sci. 35:1165.

Ratcliff, R. G., E. J. Day and J. E. Hill. 1959. Broiler pigmentation as influenced by dietary modifications. Poultry Sci. 38:1039-1048.

Scott, H. M., L. D. Matterson and E. P. Singsen. 1947. Nutritional factors influencing growth efficiency of feed utilization. I. The effect of the source of carbohydrate. Poultry Sci. 26:554.

Scott, H. M., B. C. Johnson and E. A. Goffi. 1952. Effect of surface active agents on chick growth. Poultry Sci. 31:746.

Smith, E. Y. 1949. Turkey World 24(12):11, 119, 120.

Smyth, J. R., Jr. and J. H. Vondel. 1955. The effects of diethylstilbestrol administered in a paste carrier to turkey fryers. Poultry Sci. 34:963-967.

Snyder, J. M., B. C. Johnson and H. M. Scott. 1953. Surface active agents and the time of their effect on growth with special reference to vitamin B_{12} and Aureomycin interrelationships. Poultry Sci. 32: 527:531.

Sorensen, V. L., editor. Agricultural Market Analysis. Bureau of Business and Economic Research, Graduate School of Business and Administration, Michigan State University, 1964, pp. 154-156.

Stadelman, W. J. 1952. The use of thiouracil and diethylstilbestrol in finishing turkeys for market. Poultry Sci. 31:310-315.

Stern, J. R. and J. McGinnis. 1953. Comparative growth response of chicks to detergents, germicides and penicillin. Poultry Sci. 32:26.

Sunde, M. L. 1954. The use of animal fats in poultry feed. J. Am. Oil Chem. Sco. 31:49-52.

Sunde, M. L. 1956a. A relationship between protein level and energy level in chick rations. Poultry Sci. 35:350-354.

Sunde, M. L. 1956b. The effect of fats and fatty acids in chick rations. Poultry Sci. 35:362-368.

Thayer, R. H., R. G. Jaap and R. Penquit. 1944. Fattening chickens by feeding estrogens. Poultry Sci. 23:555.

Thayer, R. H. and G. T. Davis. 1948. Use of estrogens in turkey broiler production. Poultry Sci. 27:176-181.

Thayer, R. H., K. E. Dunkelgod and D. A. Benton. 1961. Energy and protein interrelationships in turkey growing diets. Poultry Sci. 40:1079-1086.

Waibel, P. E. 1958. Effectiveness of unknown growth factors, antibiotics and animal fat in turkey poult rations. Poultry Sci. 37:1144-1149.

Yacowitz, H., R. D. Carter, J. Wyne and M. G. McCartney. 1956. Effects of varying protein and fat levels in a finishing ration for turkey broilers.