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To the Graduate Council:

I am submitting herewith a thesis written by Irvine Harvey Kidd entitled "Influence of Diet upon Broiler Quality and Consumer Acceptance of Carcasses Differing in Skin Pigmentation." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements of the degree of Master of Science, with a major in Poultry.

O E Goff
Major Professor

We have read this thesis
and recommend its acceptance:

H. V. Shirley Jr.

B. D. Raskopf

Accepted for the Council

Dale Wantling
Dean of the Graduate School

INFLUENCE OF DIET UPON BROILER QUALITY AND CONSUMER ACCEPTANCE OF CARCASSES DIFFERING IN SKIN PIGMENTATION

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the Degree of
Master of Science

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by

Irvine Harvey Kidd

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INTRODUCTION

Milo and other grain sorghums are grown in large quantities in the South, Midwest and Southwest. Production of milo and other grain sorghums has increased rapidly in the United States since 1950. In 1958, the acreage planted in grain sorghums was more than double the amount planted in 1957. In many areas these grains are lower in price than corn. This is particularly so during some seasons of the year. Feed manufacturers and broiler producers are therefore interested in the effects of including various levels of milo and grain sorghums in broiler diets.

The use of milo and other grain sorghums, as the cereal portion of broiler diets, has been tested by numerous workers. Conflicting results have been reported regarding the amount of milo which might be used in broiler diets and the influence of milo upon broiler gains and meat quality.

Corn and milo are similar in most nutritive values. However, yellow corn is a good source of vitamin A and high in xanthophyll which is responsible for the pigmentation of yellow color which is deposited in the skin, beak and shanks of yellow skin broilers. As milo is practically devoid of the carotenoid pigments, feed manufacturers tend to avoid using this grain in broiler feeds.

OBJECTIVES

The production and marketing of broilers is highly competitive. This has resulted in formulation of broiler diets using readily available ingredients that give more pounds of high quality meat with the use of less feed; and has increased the need for improvements in marketing methods. This, in turn, has increased the need for more information concerning consumer preferences and acceptance of broilers.

The experiments reported in this thesis were designed to (1) determine the effects of diets containing milo at various levels, and the use of supplements (alfalfa meal, corn gluten meal, and additional vitamin A) upon growth rate and feed efficiency of broilers; (2) measure the effects of these diets upon deposition of yellow pigment in the skin of broilers; and (3) determine consumer preference and acceptance of broilers possessing different amounts of skin pigmentation.

LITERATURE REVIEW

The pigmentation of the shanks and skin of yellow-skin breeds of broilers is a subject of practical importance in the broiler industry of this country. This importance is obvious when the size of the broiler industry is considered and the emphasis placed upon shank and skin pigmentation by feed manufacturers, producers, processors and in some instances, the consumer. Palmer (1915) first demonstrated that xanthophyll was the yellow pigment found in chicken fat. Since that time numerous investigators have confirmed this work and have shown a relationship between the xanthophyll content of feed ingredients and the intensity of yellow pigment in the shanks, skin and body fat of chickens.

Peterson, Hughes and Payne (1939) stated that the fowl will selectively utilize the carotenols, or hydroxy derivatives of the carotenes, while mammals tend to utilize the pure hydrocarbons. It is further reported that the egg yolks and body fat of the fowl contain rather large amounts of carotenols and only small concentrations of the carotenes. Fritz and Wharton (1957) indicate that the normal color of skin and body fat of chickens is due chiefly to xanthophyll (lutein) and that this pigment must be supplied in the diet when yellow color is desired in the body tissues.

Hammond and Harshaw (1941), Culton and Bird (1941), Bird (1942), have shown that the diet can decidedly influence the deposition of yellow pigment in the skin and shanks of the growing chicken.

While certain grain sorghums have been used satisfactorily in poultry diets, reports of dissatisfaction are occassionally heard. Payne

(1934) found that good quality kafir or milo could be substituted for white or yellow corn, pound for pound, in a diet for growing chickens or laying hens, when adequately supplemented with other nutrients. Melass (1943) confirmed this finding, however, he specified that milo would replace an equal weight of corn only if alfalfa meal of a good quality was included in the diet. Hammond (1942) found that either yellow milo or hegari was of equal value to white corn in a balanced diet for laying hens. Thayer, Sieglinger and Heller (1957) reported studies in which the relative feeding value of improved varieties of grain sorghums were compared to yellow corn. These research workers found that most of the grain sorghum varieties, when substituted, pound for pound, for corn in the diets used, were equal to corn in promoting chick growth. They also reported that the growing chickens fed the grain sorghum varieties utilized feed as efficiently as chicks fed yellow corn.

Harms, Quisenberry and Couch (1958) found that as yellow corn replaced milo in the diet of broilers improvement in the finish score and body weight was obtained. They also reported that an increase in deposition of skin pigment was obtained as the milo was replaced with yellow corn.

Feed is only one of several factors which has been found to affect the deposition of pigment in the skin of growing chicks. Collins, Thayer and Skoglund (1955) found that breed and strain differences existed in the amount of pigment deposited in the skin. In a study, using five strains of New Hampshires these investigators also found that environment influenced shank color.

Bird (1952) presented data from the Sixth Maine Production and Broiler Test in which all pens were fed the same diet and the chicks were dressed and scored at fourteen weeks of age. The data showed that on the basis of a pigmentation score for the dressed carcasses New Hampshires ranked first, Barred crosses ranked second and White Plymouth Rocks ranked third. Within each breed or cross there was a considerable variation among entries, and males were more heavily pigmented than the females.

Hammond and Harshaw (1941) using 3840 chicks in six experiments, found that in growing chicks the shank and skin color was influenced by breed, by the quantity of xanthophyll pigment in the diet and by the quantity of a pigment-suppressing factor in the diet. They found that the deposition of yellow pigment in the shanks of chickens is partially inhibited by the presence of fish oils in the diet. Coulton and Bird (1941) presented data indicating that certain common feedstuffs, namely: meat scraps, fish meal, soybean oil meal, contained a factor, or factors, which inhibit the deposition of yellow pigment in the shanks of growing chickens. Bird (1942) reported that dried skim milk was a more satisfactory source of animal protein than was meat or bone meal in a mash designed to produce rapid pigmentation, as the latter ingredient exhibited a pigment depressing effect.

Mann (1945) noted that diets containing fish meal depressed disposition of pigment in the legs of chicks 28 days of age.

Collins, Thayer and Skoglund (1955) stated that certain poultry diseases influenced the degree of skin and shank pigmentation. These

workers stated that bleaching of the shanks was one of the early indications of coccidiosis. Respiratory diseases also modify the degree of shank pigmentation in the growing chicken according to their reports.

Antioxidants are added to fats to prevent rancidity. Matherson et al. reported that deeper pigmentation of broilers resulted when a fat containing DPPD an antioxidant was incorporated in broiler diets. Since that time researchers have included antioxidants in broiler diets for the purpose of determining the influence upon broiler pigmentation. Reports have been conflicting. High et al. (1952) reported that a ratio of 0.5 milligram of antioxidant to 33 micrograms of carotene per day increased the deposition of vitamin A in rats. However, High et al. (1954) reported data which showed that a high ratio of antioxidants to carotene decreased the vitamin A deposition in carotene-fed rats. Berry (1958) stated that the use of DPPD (diphenyl-p-phenylenediamine) and BHT (butylated hydroxy toluene) in diets for laying hens, containing ground milo, failed to appreciable increase egg yolk color. He further stated that these products when added to broiler diets has increased the amount of yellow pigment in the skin and shanks of broilers. Harms, Quisenberry and Couch (1958) reported that the addition of DPPD to the diet of broilers was found to significantly decrease the pigmentation in the skin of broilers.

Kline, Schultz and Hart (1932) and Peterson, Hughes and Payne (1939) reported that xanthophyll will not serve as a source of vitamin A for growing chickens.

Titus (1939) reviewed the vitamin A requirements of the growing chick and stated:

> In recent years vitamin A requirement of growing chicks has been carefully studied, and it is now possible to state both the minimum requirement and approximate level of intake. The minimum requirement is about 150 International Units of vitamin A per 100 g. of feed, or about 780 Units per pound. The optimum level of intake is at least 320 International Units of vitamin A per 100 g. of feed, or about 1,450 Units per pounds. Several times this quantity may be fed without harm; and then somewhat more than this quantity can be supplied at no appreciable increase in the cost of the feed, it is recommended that this be done.

Scott (1958) stated that recent research has shown that when commercially stabilized vitamin A preparations are used the vitamin A requirement of starting chicks is no higher than 600 U. S. P. units per pound of ration. He further stated that:

> These results indicate that the true vitamin A requirements are considerably less than previously believed and that the higher apparent requirements are due to oxidative destruction of a large portion of the vitamin A when unstabilized fish oils are used in the course of determining the vitamin A requirements.

Literature reveals but little data regarding consumer preference and acceptance of broilers containing varying amounts of yellow pigment.

According to Benjamin, Pierce and Termohlen (1949) the skin color in market chickens may range from white through cream to golden yellow and even to a dark brownish yellow. White, cream or golden-yellow colors are satisfactory provided the color is uniform in all birds in the package.

Fritz and Wharton (1957) in a preliminary report found that a consumer panel favored the less deeply colored broilers. Conversely, McAllister, Kish and Bausman (1950) reported that yellow-colored birds free of bruises and blemishes appealed to most consumers.

Nybreton (1953, 1956) reported that plumpness, skin color, and cleanliness were the principle factors homemakers considered when selecting chickens. It was also reported that in a matched-lot experiment,

more thighs were sold when the meat side was exposed than when the skin side was exposed.

Weidenhamer (1957) stated that most buyers of chicken looked for one free from bruises or discoloration. Plumpness, lack of pinfeathers, and the amount of fat covering were also important considerations to most purchasers.

In many cases the value gained by producing broilers possessing a deeply pigmented skin is lost when the bird is subscalded. Raskopf (1958) stated that 41.7 percent of the broilers which were subscalded were rated as excellent by the consumer compared to 30.2 percent which were semi-scalded. Consumers further rated 20.7 percent of the semiscald broilers as fair or poor while they rated 16 percent of the subscalded birds fair or poor.

PROCEDURE

Experimental Animals

Cross-bred broiler type chicks, which were obtained from a local commercial hatchery, were used in all experiments.

Quarters and Care of Experimental Animals

Three floor experiments extending for nine weeks each and one battery experiment extending for four weeks, were conducted. At one day of age the chicks were debeaked, sexed and vaccinated for bronchitis and Newcastle disease using the intraocular method. The chicks were wing banded as a means of identification. Feed and water were supplied *ad libitium*.

Fifty male and fifty female chicks were randomly assorted into each of the twelve pens in the first two floor experiments and into each of the eighteen pens in the third floor experiment. Each 10 x 12 foot pen was equipped with three four-foot feed troughs, and one four-foot automatic watering trough. Wood shavings were used as litter. Infra-red heat bulbs were used for brooding.

In the battery experiment, six hundred chicks were randomized into forty pens. Each pen consisted of seven males and eight females. Prior to placing the chicks in the brooders heating elements were adjusted to the same level and the thermostats adjusted to operate within a range of 95-100° F. The temperature was lowered five degrees each week for the first three weeks. Feed and water trough guards were adjusted as necessary.

At four weeks of age the four replications of each treatment were

combined into one pen of approximately sixty chicks and grown to nine weeks of age on the floor. The pens were 10 x 12 feet. Each pen was equipped with two four-foot feed troughs and one three-gallon waterer. Wood shavings were used for litter. Infra-red lights were used for brooding.

Diets

A corn-soybean oil meal basal diet was used in experiments 1 and 2 (Table I). Four additional diets were formulated by replacing 25, 50, 75 and 100 percent of the corn respectively with red milo. The sixth diet, designated as the control, was formulated using yellow corn as the source of cereal grain along with 4 percent corn gluten meal and 3 percent alfalfa meal. The percent protein in all diets were essentially equal. No attempt was made to equalize energy levels in these diets. Each of the six diets were fed to three pens of broilers, each of which consisted of fifty males and fifty females.

The six experimental diets used in Experiment 3 were formulated by replacing 50 and 100 percent of the yellow corn respectively with red milo. Three of the diets contained 4 percent corn gluten meal and 3 percent alfalfa meal (Table II). Each of the six diets were fed to three pens of broilers, each of which consisted of fifty males and fifty females.

The basal diet used in Experiment 4 is shown in Table III. Eight additional diets were formulated by replacing 100 percent of the yellow corn with red milo. Six of these diets were supplemented with 3 percent corn gluten meal, 3 percent alfalfa meal or additional vitamin A, or with two or more of these feed supplements in combination. The other two diets

TABLE I

COMPOSITION OF BASAL DIET
EXPERIMENT 1 AND 2

Ingredient	Lbs/cwt
Yellow Corn	62.6
Soybean Oil Meal (50% Protein)	29.0
Fish Meal (Menhaden, 60% Protein)	2.5
Dried Whey	2.5
Ground Limestone	1.2
Defluorinated Rock Phosphate[1]	1.0
Salt	0.5
Vitamin Mix[2]	0.7

[1]Contains 34% calcium and 17% phosphorus

[2]Supplies per pound of feed: 3 mcg. vitamin B_{12}, 250 mg. chlorine chloride, 0.9 mg. riboflavin, 3 mg. calcium pantothenite, 5 mg. niacin, 2,737 I.U. vitamin A, 1,050 I.C.U. vitamin D_3, 0.08 gms. $MnSO_4$, 2 mg. procaine penicillin, 45 mg. arsanilic acid, 0.5 mg. menadione sodium bisulfite and 2.5 mg. nitrofurazone.

TABLE II

COMPOSITION OF DIETS
EXPERIMENT 3

Ingredient	Diets Lbs/cwt 1	2	3	4	5	6
Yellow Corn	58.1	30.0	——	61.0	31.5	——
Milo	——	30.0	62.0	——	31.5	65.0
Soybean Oil Meal (50% Protein)	24.0	22.1	20.1	28.1	26.1	24.1
Fish Meal (Menhaden, 60% Protein)	2.5	2.5	2.5	2.5	2.5	2.5
Dried Whey	2.5	2.5	2.5	2.5	2.5	2.5
Corn Gluten Meal	4.0	4.0	4.0	——	——	——
Alfalfa Leaf Meal	3.0	3.0	3.0	——	——	——
Ground Limestone	1.2	1.2	1.2	1.2	1.2	1.2
Defluorinated phosphate[1]	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin Mix[2]	0.7	0.7	0.7	0.7	0.7	0.7
Nitrofurazone Premix[3]	2.5	2.5	2.5	2.5	2.5	2.5

[1]Supplies 34% calcium and 17% phosphorus

[2]Supplies per pound of feed: 3 mcg. vitamin B_{12}, 250 mg. choline chloride, 0.9 mg. riboflavin, 3 mg. calcium pantothenate, 5 mg. niacin, 2,737 I.U. vitamin A, 1,050 I.C.U. vitamin D_3, 0.08 gm. $MnSO_4$, 2 mg. procaine penicillin, and 45 mg. arsanilic acid.

[3]Supplies 2.5 mg. Nitrofurazone per pound of feed.

TABLE III

COMPOSITION OF BASAL DIET
EXPERIMENT 4

Ingredient	Lbs/cwt
Yellow Corn	61.1
Soybean Oil Meal (50% Protein)	28.0
Fish Meal (Menhaden, 60% Protein)	2.5
Dried Whey	2.5
Ground Limestone	1.3
Defluorinated Phosphate[1]	1.0
Salt	0.5
Vitamin Mix[2]	0.6
Nitrofurazone Premix[3]	2.5

[1]Contains 34% calcium and 17% phosphorus

[2]Supplies per pound of feed: 0.9 mg. riboflavin, 3.0 mg. calcium pantothenate, 5.0 mg. niacin, 4.8 mcg. vitamin B_{12}, 284 mg. choline, 1,903 I.U. vitamin A, 1,050 I.C.U. vitamin D_3, 60 mg. $MnSO_2$, 2 mg. procaine penicillin and 38 mg. arsanicic acid.

[3]Supplies 2.5 mg. nitrofurazone per pound of feed.

contained water treated milo prepared by placing the whole grain milo in a large vat. Water was bubbled through for twenty-four hours in an attempt to remove tanic acid and any water soluble toxins that might be present. The washed milo was dried by placing in a chicken incubator and by spreading on a concrete floor in sunshine. The moisture content prior to washing in water was 12.24 percent but was reduced to 10.20 percent after drying. A tenth diet, designated as the control, was formulated using yellow corn as the source of cereal grain and containing 3 percent corn gluten meal and 3 percent alfalfa meal. Each diet was fed to four pens of chicks, each of which consisted of seven males and eight females.

All diets formulated for Experiment 3 and 4 were adjusted to be iso-nitrogenous and iso-caloric by varying the amounts of yellow corn and/or milo, soybean oil meal or with the addition of animal fat. The energy level of each diet was calculated using productive energy values according to Titus (1955).

Data Obtained and Methods of Collection

Experiments 1 and 2: At the termination of experiments 1 and 2, all birds were individually weighed and the feed efficiency calculated by determining pounds of feed consumed per pound of live broiler produced. Random samples of fifteen birds from each pen were slaughtered in the Poultry Processing Laboratory, and each bird scored visually for deposition and intensity of pigment in the skin of the breast and thighs. Scoring was one to six, with six indicating the more deeply pigmented birds. In both experiments a standard was obtained by

selecting birds ranging from the least to the greatest amount of pigmentation.

Seventy-five birds were slaughtered from the groups receiving the diet containing all milo as the only source of cereal grain; fifty percent milo and corn as the cereal grains, and seventy-five birds from the group receiving the control diet. These broilers were subsequently used in consumer preference and acceptance tests.

Experiment 3: At the termination of the experiment all birds were individually weighed, scored for pigmentation and the feed efficiency determined by calculating the pounds of feed required to produce a pound of live broiler. A sample (first ten males) from each pen was visually scored for deposition of skin pigment and feathering. Scoring for pigmentation was one to four, with four indicating the more deeply pigmented birds. Scoring for feathering was one to three, with three being the best feathered birds. After slaughter, the birds were again scored for pigmentation and evicerated weights were obtained. The live weight of the birds was obtained when the birds were moved from the brooder house to be slaughtered. Evicerated weight was obtained after removal of the shanks at the hock joints; removal of the head near the atlas joint; removal of all edible and inedible visera except the kidneys.

In addition to the 120 broilers studied in detail four hundred and fifty birds (seventy-five from each treatment) were slaughtered and used to determine consumer acceptance of broilers varying in degrees of skin pigmentation. The birds were divided into three groups of one hundred and fifty each according to deposition of skin pigmentation, ie, deep, medium, and light pigmentation or birds lacking in pigmentation.

Experiment 4: At four and nine weeks of age all birds were individually weighed and the feed efficiency determined. Each bird was visually scored for deposition of pigment and feathering. Scoring for both pigmentation and feathering was one to four with four indicating the more deeply pigmented and better feathered birds respectively.

Consumer Preference and Acceptance Studies

A consumer preference and two consumer acceptance studies were conducted. These studies were conducted in two of the larger Knoxville, Tennessee chain stores. Factors of price, quality, and packaging were held constant with weights ranging from 1.75 to over 2.50 pounds. All birds were dejointed and packaged using a transparant wrap.

Consumer Preference Study

Broilers from experiment 1 were used in this study. Birds of all three degrees of pigmentation were offered for sale at the same time. The birds were displayed in a randomized block design and were immediately replaced by others of the same skin color as purchased by customers. The duration of the study was one day.

Consumer Acceptance Studies

For the two studies, a display of broilers of only one degree of skin pigmentation was displayed during each twenty-minute randomized interval. The first study continued through one work day while the second was continued for two days. Each display consisted of approximately forty broilers. As the birds were sold they were replaced with other broilers of the same degree of skin pigmentation.

Statistical Treatment

Body weights, feed efficiency, evicerated yield, pigmentation and

feathering scores were analyzed using analysis of variance according to Snedecor (1956) with significant treatment differences determined by Duncan's multiple range test (1955).

RESULTS AND DISCUSSION

Experiments 1 and 2:

The average body weight of broilers was decreased when milo replaced more than 25 percent of the yellow corn in their diet (Table IV). In experiment 1 the average body weight of the birds receiving the diet containing yellow corn as the only cereal grain was significantly heavier than those receiving diets containing either 50, 75 or 100 percent of the cereal grain as milo. No significant difference was found between the average body weight of the broilers receiving the diet in which yellow corn was the only source of cereal grain and the group receiving the diet containing 75 percent yellow corn and 25 percent milo as the cereal portions of the diet. The nine-week weight of broilers receiving the diet containing milo as the only cereal grain was significantly less than any other group.

The same trends in body weight were observed in experiment 2, although the differences in treatment means were not so great. The average body weight of broilers receiving diets containing 50, 75, and 100 percent yellow corn as the source of cereal grain, were found to be significantly heavier than those receiving diets containing zero or 25 percent of the cereal as yellow corn in their diets. No difference in body weight was detected between groups of broilers receiving zero and 25 percent yellow corn as the cereal portion of their diet.

No significant differences in feed efficiency could be detected between any of the groups. However, it may be noted that as the amount of corn was increased in the diet the utilization of feed tended to be

TABLE IV

EXPERIMENT 1 AND 2

AVERAGE NINE WEEK BODY WEIGHT AND FEED EFFICIENCY OF BROILERS FED DIETS CONTAINING VARIOUS LEVELS OF MILO

Diet Cereal as Milo	Average Body Weight[1] (grams)		Lbs. Feed/Lb. Broiler	
Percent	Exp. 1	Exp. 2	Exp. 1	Exp. 2
100	1,256 [d]	1,213 [b]	2.50	2.44
75	1,357 [b,c]	1,210 [b]	2.47	2.54
50	1,356 [b]	1,247 [a]	2.49	2.53
25	1,384 [a, c]	1,231 [a]	2.48	2.52
0	1,400 [a]	1,252 [a]	2.45	2.50
Control	1,377	1,216	2.51	2.56

[1] Body weights with the same super script are not significantly different at the 5 percent level of probability.

improved, which is associated with the size or growth rate of chicks (Table IV).

The amount of yellow pigment deposited in the skin of broilers was significantly increased with each increase of yellow corn in the diet, with the most deeply pigmented birds being those fed the control diet, which contained in addition to yellow corn, 4 percent corn gluten meal and 3 percent alfalfa leaf meal; resulting in a greater carotenoid pigment content in the feed (Table V).

Titus (1955) indicated that milo contains 1,099 Calories of productive energy per pound of feed as compared with 1,105 Calories for yellow corn. This small difference in energy content of the two feed ingredients might account for some difference in growth rate, however, it is believed to be insufficient to account for all of the difference in body weight. This would suggest that either the difference in energy value of these grains is greater than suggested by Titus (1955) or that some other factor limits the growth of broilers when milo is incorporated into the diet.

In experiment 1, the consumer preference study showed that 43.4 percent of the customers purchased the more deeply pigmented broilers (Table V). However, 22.5 percent of the customers purchased the broilers completely devoid of yellow pigment indicating that some customers prefered or would accept birds lacking in yellow color. Broilers of medium pigmentation were selected by 34.1 percent of the customers.

The consumer preference study showed that some consumers desired broilers possessing various degrees of pigmentation therefore a consumer

TABLE V

EXPERIMENT 1 AND 2

EFFECTS OF FEEDING DIETS CONTAINING VARIOUS LEVELS OF MILO UPON PIGMENTATION, CONSUMER PREFERENCE AND ACCEPTANCE OF BROILERS

Cereal as Milo	Pigmentation Score[1]		Consumer Preference Volume Sold		Consumer Acceptance Volume Sold	
Percent	Exp. 1	Exp. 2	Exp. 1 Number	Exp. 2 Percent	Exp. 1 Number	Exp. 2 Percent
100	1.15	1.19	39	22.5	46	33.6
75	2.04	2.16				
50	2.67	2.94	43	34.1	43	31.4
25	3.44	3.29				
0	4.44	3.61				
Control	5.08	4.43	75	43.4	48	35.0

[1]Scoring ranged from one to six with six being the more deeply pigmented.

acceptance study was designed. In the consumer acceptance study, a display of broilers of only one degree of pigmentation was offered for sale during 20-minute randomized intervals. No significant difference existed in the percentage of broilers sold according to the degree of pigmentation for the entire twelve hour period (Table V). Of the 137 broilers sold, 33.6 percent were of the least degree of pigmentation, 31.4 percent of medium pigmentation and 35.0 percent showing deep pigmentation. These data indicate that some customers would accept broilers of any degree of skin pigmentation or that other factors might be of more importance than skin color.

Experiment 3:

Substitution of milo for all of the corn in the diet of broilers appeared to limit body weight gains (Table VI). The birds in the group receiving 100 percent milo as the only cereal grain were significantly lighter in body weight than any other group of birds in the experiment. The broilers receiving 100 percent yellow corn, as the only cereal grain were the heaviest birds with an average body weight of 1,448 grams. However, no significant difference was found to exist between the group receiving 100 percent of the cereal grain as yellow corn, plus alfalfa meal and corn gluten meal; the group receiving 100 percent of the cereal grain as yellow corn without the supplements and the group receiving 50 percent of the cereal grain as milo, without the supplements. Neither was there a significant difference between the group receiving 50 percent of the cereal grain as milo including alfalfa meal and corn gluten meal and the group receiving 100 percent of the

TABLE VI

EXPERIMENT 3

AVERAGE NINE WEEK WEIGHT, FEED EFFICIENCY AND LIVABILITY OF BROILERS FED DIETS CONTAINING VARIOUS LEVELS OF MILO, ALFALFA MEAL AND CORN GLUTEN MEAL

COMPOSITION OF DIET					
Cereal as Milo Percent	Alfalfa Meal Percent	Corn Gluten Meal Percent	Average Body Weights[1] Grams	Lbs. Feed/Lb. Broiler	Livability Percent
100	3	4	1,411 [c]	2.57	98.67
100	0	0	1,276 [d]	2.67	98.00
50	3	4	1,427 [b,c]	2.68	98.67
50	0	0	1,447 [a]	2.68	99.33
0	3	4	1,441 [a,b]	2.64	99.67
0	0	0	1,448 [a]	2.52	98.67

[1]Body weights with the same super script are not significantly different at the 5 percent level of probability.

cereal grain as milo, with the supplements. Statistically, the group receiving 50 percent of the cereal grain as milo, with the supplements, and the group fed a diet containing 100 percent of the cereal grain as milo, including the supplements, were equal in body weight gains. The group receiving the diet containing milo as the only source of cereal grain, plus alfalfa meal and corn gluten meal was significantly lighter in average body weight than the groups receiving 100 percent of the cereal grain as corn, either with or without the supplements, and the group fed 50 percent of the cereal grain as milo, excluding the supplements.

The addition of 3 percent alfalfa meal and 4 percent corn gluten meal significantly improved the growth rates of chicks fed diets in which milo replaced all of the yellow corn as the cereal portion of the diet (Table VI). However, when 50 percent of the yellow corn was replaced with milo the addition of alfalfa meal and corn gluten meal gave a lower average body weight gain (1,427 grams) than did the diet containing 50 percent of the cereal grain as milo without the supplements (1,447 grams). The group of birds receiving 100 percent of the cereal grain as corn without the alfalfa meal and corn gluten meal averaged 1,448 grams compared to 1,441 grams for those receiving the diet containing corn as the only source of cereal grain and including the supplements. Livability was high in all groups of broilers and no statistical differences were observed between any of the treatments (Table VI).

No significant difference in eviscerated yield was detected

between any of the groups of broilers (Table VII). The percent eviscerated yield of the broilers receiving the diet containing 100 percent of the cereal grain as yellow corn supplemented with 3 percent alfalfa meal and 4 percent corn gluten meal was 61.78 as compared to 59.61 for the group receiving the diet containing milo as the only source of cereal grain and supplemented with 3 percent alfalfa meal and 4 percent corn gluten meal. There was no apparent difference between the size of the live birds and the eviscerated yield as observed in this experiment.

Deposition of yellow pigment in the skin and shanks of the broilers was significantly increased with the addition of 3 percent alfalfa meal and 4 percent corn gluten meal to the diet containing either 50 or 100 percent milo as the cereal portion (Table VIII). The increase in the amount of yellow pigment deposited in the skin and shanks of broilers receiving the diets containing corn as the only cereal grain but supplemented with the alfalfa meal and corn gluten meal was not significant. The same results were observed for the sample of broilers (first ten males from each pen) that were slaughtered for a more detailed study (Table VII). It was observed that the pigmentation scores were slightly lower for all groups after processing, with the exception of the group receiving 100 percent of the cereal portion of their diet as milo. As this latter group was practically devoid of yellow pigment, thus there was little or none lost during processing. This is in agreement with the report of Raskopf (1958). It was also noted that the males were slightly more deeply pigmented than the females (Table VIII). However, this difference in pigmentation was not significant. These observations

TABLE VII

EXPERIMENT 3

EFFECTS OF FEEDING DIETS CONTAINING VARIOUS LEVELS OF MILO, ALFALFA MEAL AND CORN GLUTEN MEAL UPON NINE WEEK BODY WEIGHT, EVISCERATED YIELD AND PIGMENTATION SCORE OF BROILERS[1]

COMPOSITION OF DIET			AV. BODY WEIGHT		EVISCERATED YIELD	PIGMENTATION SCORE	
Cereal as Milo	Alfalfa Meal	Corn Gluten Meal	Live	Eviscerated			
Percent	Percent	Percent	Ounces		Percent	Live	Dressed
100	3	4	56.13	34.23	59.61	2.83	2.73
100	0	0	49.53	30.43	61.40	1.00	1.00
50	3	4	55.13	33.50	60.87	3.70	3.48
50	0	0	56.87	34.63	60.32	3.00	2.73
0	3	4	56.50	36.13	61.78	3.83	3.77
0	0	0	56.50	35.13	60.61	3.57	3.27

[1]First ten males from each pen.

[2]Scoring ranged from one to four with four being the more deeply pigmented.

TABLE VIII

EXPERIMENT 3

EFFECTS OF FEEDING DIETS CONTAINING VARIOUS LEVELS OF MILO, ALFALFA MEAL AND CORN GLUTEN MEAL UPON PIGMENTATION AND CONSUMER ACCEPTANCE OF BROILERS

COMPOSITION OF DIET			PIGMENTATION SCORE[1]			CONSUMER ACCEPTANCE	
Cereal as Milo	Alfalfa Meal	Corn Gluten Meal	M	F	Av.	Volume Sold	
Percent	Percent	Percent				Number	Percent
100	3	4	2.30	2.20	2.25		
100	0	0	1.01	1.00	1.01	154	38.7
50	3	4	3.79	3.69	3.74		
50	0	0	2.77	2.73	2.75	124	31.2
0	3	4	3.63	3.51	3.57		
0	0	0	3.60	3.45	3.53	120	30.1

[1]Scoring ranged from one to four with four being the more deeply pigmented.

are in agreement with Bird (1952).

In the third consumer study, designed in the same manner as the second study (a consumer acceptance study), broilers of only one degree of pigmentation were offered during 20-minute randomized intervals. Of the 398 broilers sold, 38.7 percent were of the least degree of pigmentation, 31.2 percent of the medium pigmentation and 30.1 percent deeply pigmented. These differences were significant. This difference was in favor of the broilers of least skin pigmentation (Table VIII). These data, as well as data from the other consumer acceptance study, indicate that some customers would accept broilers of any pigmentation. Based upon these data it is questionable as to the degree of emphasis that should be placed upon skin pigmentation of broilers.

Experiment 4:

The average body weight and feed efficiency at four weeks of age are shown in Table IX. The average body weight per chick receiving the basal diet and the control diet was 423.2 grams and 427.3 grams respectively. The average weight per chick for these two groups of broilers were not significantly different from the group receiving the diet containing 100 percent milo, as the cereal portion of the diet, which was water treated and contained 3 percent alfalfa meal and 3 percent corn gluten meal. Neither did they differ from the group of broilers receiving the diet containing milo as the only cereal grain, which was untreated, but contained both alfalfa meal and corn gluten meal. Neither of the two groups of broilers which were fed diets containing milo as the only cereal grain, treated or untreated, and

TABLE IX

EXPERIMENT 4

AVERAGE FOUR-WEEK BODY WEIGHT AND FEED EFFICIENCY OF BROILERS FED DIETS CONTAINING MILO AND VARIOUS SUPPLEMENTS

COMPOSITION OF DIET				
Cereal as Milo Percent	Alfalfa Meal Percent	Corn Gluten Meal Percent	Average Body Weight[1] (grams)	Lbs. Feed/Lb. Broiler
0	0	0	423.2[a]	1.73
0	3	3	427.3[a]	1.66
100	0	0	395.8 [b]	1.80
100	3	0	402.1 [b,c]	1.73
100	0	3	407.5 [b,c]	1.80
100[2]	0	0	407.1 [b,c]	1.73
100	3	3	416.2[a, c]	1.81
100[3]	3	3	403.3 [b,c]	1.81
100[4]	0	0	408.9 [b,c]	1.72
100[4]	3	3	419.6[a, c]	1.66

[1]Body weights with the same super script are not significantly different at the 5 percent level of probability.

[2]Additional 2000 I. U. vitamin A supplied per pound of feed.

[3]Additional 1000 I. U. vitamin A supplied per pound of feed

[4]Water treated milo.

including the alfalfa meal and corn gluten meal were significantly different from groups receiving diets containing water treated milo without the supplements; milo plus corn gluten meal; milo plus additional vitamin A; milo plus alfalfa meal or milo plus all three of the supplements. However, the groups of birds receiving yellow corn in the diet were significantly heavier in average body weight than those groups receiving diets containing water treated milo without the supplements; milo plus corn gluten meal; milo plus additional vitamin A; milo plus alfalfa meal; milo plus all three of the supplements or untreated milo without any of the supplements.

The group of broilers receiving 100 percent of the cereal grain as untreated milo without alfalfa meal and corn gluten meal or additional vitamin A were significantly lighter in body weight than the group receiving diets containing yellow corn, or the group receiving 100 percent of the cereal grain as milo, treated or untreated, which contained alfalfa meal and corn gluten meal.

The vitamin A content of the diets ranged from a minimum of 1,903 I. U. per pound in the diet containing 100 percent of the cereal grain as milo without alfalfa meal and corn gluten meal to a miximum of 4,363 I. U. per pound in the diet containing 100 percent of the cereal grain as milo, plus alfalfa meal and corn gluten meal. The addition of 2,000 I. U. of vitamin A to the diet containing milo as the only cereal grain, or 1,000 I. U. of vitamin A to the same diet containing alfalfa meal and corn gluten meal gave only a slight body weight gain at the end of the fourth week. This increase in average body weight gain was 6.3 and 7.5

grams respectively which was not significantly different at the 5 percent level of probability.

The addition of 3 percent alfalfa meal and 3 percent corn gluten meal to the water treated milo and the untreated milo, when fed to broilers, gave an increase in average body weight gains comparable to the diets containing yellow corn. However, when additional vitamin A was added to the milo diet containing alfalfa meal and corn gluten meal the response was only very slight. Data are interpreted to indicate biological variability and not determental effects of added vitamin A, as Titus (1939) stated that 1,450 I. U. of vitamin A per pound of feed was the optimum level but that several times this quantity might be fed without harm.

No significant differences in feed efficiency could be detected at four weeks of age (Table IX).

The average body weight and feed efficiency at nine weeks of age are shown in Table X. The two groups of broilers receiving yellow corn in their diets were the heaviest birds with average body weight of 1,392 and 1,375 grams. The group receiving a diet containing milo as the only cereal grain, without supplements, were the lightest in weight with an average body weight of 1,270 grams. There were no apparent differences in feed efficiency between any of the groups of broilers at nine weeks of age.

The broilers receiving the diets containing corn were the most deeply pigmented and the broilers receiving milo were practically devoid of pigmentation (Table XI). The addition of alfalfa meal or corn gluten

TABLE X

EXPERIMENT 4

AVERAGE NINE-WEEK BODY WEIGHT AND FEED EFFICIENCY OF BROILER FED DIETS CONTAINING MILO AND VARIOUS SUPPLEMENTS

COMPOSITION OF DIET				
Cereal as Milo Percent	Alfalfa Meal Percent	Corn Gluten Meal Percent	Average Body Weight[1] (grams)	Lbs. Feed/ Lb. Broiler
0	0	0	1,375	2.49
0	3	3	1,392	2.48
100	0	0	1,270	2.63
100	3	0	1,310	2.46
100	0	3	1,308	2.56
100[1]	0	0	1,318	2.69
100	3	3	1,324	2.67
100[1]	3	3	1,274	2.69
100[1]	0	0	1,294	2.55
100[1]	3	3	1,319	2.48

[1]Refer to Table IX

TABLE XI

EXPERIMENT 4

EFFECTS OF FEEDING DIETS CONTAINING MILO AND VARIOUS SUPPLEMENTS UPON BROILER PIGMENTATION AND LIVABILITY

COMPOSITION OF DIET			PIGMENTATION SCORE[1]			LIVABILITY	
Cereal as Milo Percent	Alfalfa Meal Percent	Corn Gluten Meal Percent	M	F	Av.	4 Wk. Percent	9 Wk. Percent
0	0	0	2.96	2.32	2.64	100.0	96.7
0	3	3	3.70	3.13	3.42	96.7	96.7
100	0	0	1.00	1.00	1.00	100.0	96.7
100	3	0	1.96	1.71	1.84	100.0	98.3
100	0	3	1.96	1.59	1.78	100.0	98.3
100[2]	0	0	1.00	1.00	1.00	100.0	98.3
100	3	3	2.11	2.03	2.07	95.0	95.0
100[2]	3	3	2.31	2.19	2.25	98.3	98.3
100[2]	0	0	1.00	1.00	1.00	96.7	96.7
100[2]	3	3	2.48	2.28	2.38	96.7	96.7

[1]Scoring ranged from one to four with four being the more deeply pigmented.

[2]Refer to Table IX.

meal or both of these gave a significant increase in deposition of yellow color in the shanks and skin of broilers fed these diets. The addition of vitamin A was ineffective in increasing the deposition of xanthophyll.

The percent of livability was high in all treatments at four and nine weeks of age with no apparent differences between the various treatments.

SUMMARY

The results of three floor experiments extending over a period of nine weeks, involving 4,200 broilers, and an experiment, involving 600 broilers to four weeks of age in battery brooders and five weeks on the floor, are reported. The results are given on one consumer preference study and two consumer acceptance studies, which were conducted to determine consumer reaction to broilers varying in skin pigmentation.

Diets in which red milo was substituted for yellow corn, with or without supplements (alfalfa meal, corn gluten meal or additional vitamin A) were formulated. These diets were fed to broilers to evaluate the effects of these feed ingredients upon growth rate, feed efficiency, livability and deposition of yellow pigment in the skin and shanks.

A decrease in body weight of broilers was obtained as yellow corn was replaced with milo. However, the addition of alfalfa meal and corn gluten meal in diets containing milo tend to prevent this decrease in body weight gains of broilers fed these diets. Supplementing broiler diets, containing milo, with additional vitamin A failed to appreciably increase body weight gains.

The substitution of milo for corn in the diet of broilers failed to significantly affect feed efficiency. The addition of alfalfa meal and corn gluten meal tended to improve feed efficiency only in broiler diets in which milo replaced all the corn.

Significant differences in livability of chicks was undetected between groups receiving various levels of corn or milo, with or without

supplements.

The amount of yellow pigment deposited in the skin and shanks of broilers was significantly increased with each increase of yellow corn in the diet. The most deeply pigmented broilers in all experiments were those receiving corn as the only cereal grain or corn plus alfalfa meal and corn gluten meal. The addition of alfalfa meal and/or corn gluten meal to the diets containing milo significantly increased deposition of xanthophyll in the skin and shanks of broilers.

The addition of vitamin A to diets containing milo failed to increase pigmentation in the skin and shanks of broilers fed these diets. It was found that the males were slightly more deeply pigmented than the females except in those groups which received a diet containing milo as the only cereal grain and, without supplements of alfalfa meal or corn gluten meal resulting in a diet low in carotenoid pigment content.

Eviscerated yields of broilers receiving diets containing, corn or milo, with or without alfalfa meal and corn gluten meal, were not significantly different.

Data collected during the consumer preference study indicated that the more deeply pigmented broilers were selected by 43.4 percent of the customers who purchased broilers, whereas, 22.5 percent of the customers purchased broilers that were practically devoid of yellow color.

No significant difference existed in the percentage of broilers sold according to skin pigmentation in the first consumer acceptance study. However, in the second consumer acceptance study a significant difference existed in the percentage of broilers sold with respect to

skin pigmentation. This difference was in favor of the broilers of least skin pigmentation. These data indicate that the degree of skin pigmentation in broilers is not the primary factor with which the consumer is concerned.

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