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Growth and quality of broilers from peanut oil-peanut meal diets

Bharat Manu Shah

To the Graduate Council:

I am submitting herewith a thesis written by Bharat Manu Shah entitled "Growth and quality of broilers from peanut oil-peanut meal diets." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science and Technology.

M.R. Johnston, Major Professor

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To the Graduate Council:

I am submitting herewith a thesis written by Bharat Manu Shah entitled "Growth and Quality of Broilers from Peanut Oil-Peanut Meal Diets." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology.

Melvin K. Palmer
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We have read this thesis and
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GROWTH AND QUALITY OF BROILERS FROM PEANUT OIL-PEANUT MEAL DIETS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Bharat Manu Shah

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CHAPTER I

INTRODUCTION

The effect of supplemental fat in the poultry diet is of economic interest to poultry producers. Lard, beef tallow, stabilized yellow grease, and fancy bleachable fat have been used extensively. Soybean oil and corn oil also have been used successfully. Peanut oil is an additional source of fat for the poultry diet.

Fats are known to make two important nutritional contributions: (a) energy, and (b) essential fatty acids. Growth rate and efficiency of food utilization are the main basis for evaluating the effect of supplemental fat in the growing chick diet. Some fats and feed ingredients have been found to impart their natural flavor to the cooked meat. Consequently, organoleptic evaluation of the finished product is essential in ascertaining the desirability of using a supplemental fat.

In different parts of the world, especially in the tropics where the environment is not suitable for the soybean crop, the peanut crop is foremost. The correlated use of peanut oil as a fat source and peanut meal as a sole protein source for the poultry diet seems economically advantageous. In the Afro-Asian countries, peanut meal is being used experimentally as a protein supplement for human nutrition, and refined peanut oil is used extensively for cooking purposes. In these countries, commercialization of poultry husbandry is at an early stage. Profitable

use of indigenous products in the poultry industry would be of prime interest at this time.

This experiment was conducted to evaluate the effect of peanut meal (50 per cent protein) and peanut oil in broiler diets on growth, feed efficiency, characteristics of deposited fat and organoleptic characteristics of the roasted white and dark meat.

CHAPTER II

REVIEW OF LITERATURE

I. FATS AND OILS

Research work on supplemental fat in poultry diets has reflected beneficial as well as deleterious effects. Using 20 and 28 per cent protein in chick rations supplemented with 0, 5, and 10 per cent white grease, Sunde (39) observed that a high protein low energy diet caused a reduction in the growth rate and a reduced efficiency of feed utilization. Raising the energy level of this diet by the addition of fat increased the weight of the chicks and improved feed utilization. Biely and March (5) reported that the addition of 5.0 and 7.5 per cent tallow to a 19 per cent protein diet depressed growth and feed efficiency. With a 24 per cent protein diet, growth and feed efficiency were enhanced.

The energy level of the diet has been shown by many workers to influence the protein level required as measured by growth rate, feed consumption, and body composition. Donaldson et al. (11) reported that feed conversion and growth were impaired when the ratio of Calories of productive energy per pound for each 1 per cent protein (Calorie: protein ratio) exceeded 43.9, 48.6, and 53.7 on the low, medium, and high fat diets, respectively. As the energy-protein ratio was increased, less dietary protein and more dietary energy were required per unit of gain. Donaldson et al. (11) also reported that the methionine requirement of

chicks increased as the energy level of the ration was raised. Isaacks et al. (20) studied the growth stimulation of high levels of soybean oil added to rations consisting of cerelose and isolated soybean protein. Calories: protein (C:P) ratios of 42 and 50 were used at levels of 10, 20, 30, 40, and 46 per cent of soybean oil. They reported that the birds fed 40 and 46 per cent soybean oil rations showed 17.5, 35.6, and 37.1 per cent growth responses over the basal ration, respectively, regardless of C:P ratio. Feed efficiency was improved by 21.9, 29.3, and 32.9 per cent. Isaacks et al. (20) also reported that their studies with corn oil and rice oil indicate similar responses. They observed no beneficial effect of varying the vitamin and/or mineral levels according to the energy levels of the diet. Marion et al. (24) reported that the feed efficiency was greatest on the high protein high fat diet and lowest on the low protein low fat diet. Stephens et al. (38) prepared a finisher diet by adding 6.4 pounds of stabilized animal fat to one hundred pounds of starter diet, which had a C:P ratio of 48.5. They reported that the broilers that were fed the above diet utilized the feed more efficiently than did those fed the starter diet. No significant difference was observed in growth rate and dressing percentage. Experimenting with diets containing 20, 25, and 30 per cent protein and each being supplemented with 0, 7, and 14 per cent of stabilized animal fat, Scott et al. (35) reported that in the absence of supplemental fat, only minor differences in growth were noted for the three levels of protein. Growth from a 20 per cent protein diet progressively declined with each increment of fat.

Supplementing the 25 and 30 per cent protein diets with 7 per cent fat improved growth slightly but 14 per cent caused growth to decline. They also reported that each level of protein feed conversion was progressively improved with each increment of fat for all protein levels. Work by Essary et al. (15) showed that chicks fed rations containing higher levels of fat in relation to the level of protein (wider C:P ratios of 45.1 to 50.1 and higher productive energy levels) deposited significantly more fat in the carcass. Female broilers fed these higher energy rations deposited more fat than the males. Feeding diets with C:P ratios ranging from 35.7 to 42.8 resulted in no significant difference in fat deposition between lots and sexes. By the Duncan's multiple range F test, Newell et al. (28) concluded that maximum fat deposition may occur with an added fat level somewhere between 10 and 15 per cent.

Isocaloric substitution of fat to chick diets and/or adjustment of fat supplemented diets to isonitrogeneous levels have been tried by some workers. Donaldson et al. (12) reported that when rations which had C:P ratios ranging from 35.7 to 48.6 were fed to growing chicks for four weeks, the increased calorie levels in isonitrogeneous rations reduced feed consumption, but efficiency of calorie utilization became progressively poorer. Rand et al. (30) reported that when chicks were fed isonitrogeneous-isocaloric diets, the substitution of fat calories for glucose calories resulted in improved weight gains, greater protein and energy utilization, and protein retention. Baldini and Rosenberg (4) reported that growth responses to beef tallow did not occur when energy

levels of diets containing added fat were maintained isocaloric to that of the low-fat basal diet by the addition of cellulose. Only when the caloric density was allowed to increase was a growth response observed. Vondell and Ringrose (43) reached similar conclusions from experiments with animal fat.

Environment also has been thought to play some role in the effectiveness of supplemental fat. Feeding rations containing 0, 5, 10, and 15 per cent fat to chicks, Bigbee et al. (6) reported good growth and feed efficiency, especially in cold weather. No significant change was observed in the summer.

Extent of molecular saturation and degree of fat absorption seem to be correlated. Incorporating certain vegetable oils and animal fats in a practical type broiler diet at levels from 5 to 20 per cent, Williams et al. (46) observed that the digestibility coefficients of vegetable oils were significantly greater than those of animal fat, regardless of the level of fat added to the diet. The "apparent" digestibility coefficient of added fat increased as the fat level in the diet was increased. In contrast to the above, Laveille and Fisher (21) reported greater body weight for the animal fat (10 per cent) groups as compared to the control lots (no fats), and particularly when compared to the corn oil (10 per cent) groups, indicating an abnormal fat deposition induced by dietary animal fat. Commenting on the use of saturated fats in the chick diet, Artman (2) reported that the utilizability of relatively saturated fats, or fatty acids, is increased by mixing them with

relatively unsaturated fats or fatty acids.

The Particulate Theory of fat absorption as explained by Renner and Hill (32) maintains that it is the attachment of fatty acids to the triglyceride molecule rather than the overall proportion that causes most improvement in utilization and perhaps the extent to which they remain attached determines the absorbability of the fat.

Work by Sunde (39) showed that oleic acid, linolenic acid, and linoleic acid did not affect the growth rate but they improved feed utilization. The incorporation of 5 per cent hydrogenated fat or stearic acid in the diet did not improve the feed utilization. He concluded that the chicks did not utilize the saturated long chain fatty acids provided by these materials. Carver et al. (7) reported that hydrogenated fat is no better absorbed in the presence of partially unsaturated fat than when present alone in the chick diet.

Hopkins and Nesheim (19) reported that the responses of chicks to soybean oil fatty acids can be duplicated by linoleic acid under experimental conditions. They also showed that the relative growth-promoting properties of safflower and olive oil were directly related to their linoleic acid content. On the basis of decreasing growth action, Thomassion (42) puts soybean oil, peanut oil, and palm oil in one category. Lard, beef fat, olive oil, and cottonseed oil have greater decreasing growth action.

Hilditch (18) reported fatty acid composition of peanut oil to be 20 per cent saturated, oleic acid 53 per cent and linoleic acid 27 per

cent. Morris et al. (27) reported that the free fatty acids of the oil extracted from raw peanuts varied from 0.1 to 0.6 per cent, the average value (20 batches) being 0.23 per cent.

Arscott and Sather (3) tested broilers that were fed a 21 per cent protein ration supplemented with 3, 6, and 9 per cent of prime tallow. The broilers were oven cooked. Taste panel evaluations were made by a scoring method. No significant difference was observed in per cent cooking loss and drip loss. No consistent difference could be detected in flavor or juiciness. There was no difference in tenderness as measured by the Maryland Shear Press. Broilers fed about 8.5 per cent stabilized animal fat in experiments by Stephens et al. (37) were not significantly different from the control in evaporation loss during oven cooking. Broilers, under experiments by Dawson and Essary (10) were fed soybean oil at 5 and 10 per cent levels. Birds were wrapped in vacuum type moisture-proof film and held for nine months at 0° to -5°F. After six and nine months the birds were cooked and organoleptically evaluated. No differences in organoleptic values were observed for either of the dietary fat level during storage. Also, there was no difference in peroxide values.

Comparison of dietary and carcass fat has been tried by simple physical and chemical analysis of both. Iodine value is recognized to be a good measure of comparing saturation of lipids. Mickelberry et al. (26) reported that the observed differences between the carcass fat and ether extracts were borne out by the iodine values. The overall effect

was to shift the body iodine value toward that of the diet fat. Fingenbaum and Fisher (16) and Marion and Woodroof (23) showed that the dietary fat affects body fat composition. Reiser (31) found that the fat reserves deposited in chick were very similar to other tissue fats. Machlin et al. (22) suggested that polyunsaturated fatty acids are synthesized in the chicken body, and, therefore, the body fat composition may vary from the dietary fat.

II. PEANUT MEAL

Peanut meal is defined as a ground peanut cake (the product obtained after the extraction of part of the oil by pressure or solvents from peanut kernals as produced under reasonable milling conditions) provided that nothing shall be recognized as such that contains more than eleven per cent crude fibre. It must be designated and sold according to its protein content (17). Extensive studies have been conducted on effectiveness of animal diets in which peanut meal has been used as a substitute for part of the animal protein supplement or as a part or sole source of protein in place of vegetable protein concentrate.

Rose (34) has reviewed the subject very thoroughly. He concluded that peanut meal was deficient in lysine and methionine. He reported the supplementation of the above amino acids to a corn-fish meal-peanut meal diet to give a total of 1.04 per cent lysine and 0.58 per cent methionine would result in satisfactory growth and feed efficiency of broiler chicks. However, he concluded that the growth rate of chicks which were

fed soybean oil meal as the major protein source were seldom approached by those from the supplemented peanut meal diets. Waldrop and Harms (43) reported similar results. Peanut meal was found deficient in lysine, methionine, and tryptophane. They reported that the poor performance of chicks grown on the peanut meal diet was due to an amino acid limitation and not to any inhibiting factor in the peanut meal, since increased levels of the peanut meal resulted in increased growth.

CHAPTER III

MATERIALS AND METHODS

I. FEED MATERIALS AND DIETS

Cross-bred (Vantress x Arbor Acre 50) broiler type chicks were used in this experiment. Chicks were sexed at one day of age, vaccinated against Newcastle disease and infectious bronchitis with a combination intraoccular vaccine, and wingbanded.

The grade and quality of the ingredients used in the diets are given in Tables I and II.

Basic formulation of diets was made as follows:

Diet BR5 (Table III) was used as a control. Peanut meal was substituted for soybean oil meal and the diet was fortified with 0.4 per cent DL-methionine and 0.4 per cent L-lysine. Such additions were adjusted by reducing the corn content to make a batch formula of 100 pounds. The diet was designated as BR45 (Table III).

Peanut meal and peanut oil were substituted for soybean meal and animal fat, respectively, in the control diet BR5, and the diet was fortified with 0.4 per cent DL-methionine and 0.4 per cent L-lysine. The diet was designated as BR46 (Table III).

To 100 pounds of BR5 and BR45 was added 10 pounds of animal fat to make the diets designated as BF7 and BF12 (Table III) respectively. To 100 pounds of BR46 was added 10 pounds of peanut oil to make the diet

TABLE I

GRADE AND QUALITY OF THE INGREDIENTS
USED IN THE PREPARATION OF DIETS

Ingredients	Grade and Quality
Yellow corn	U.S. No. 2
Fish meal:anchovie	66 % protein
Alfalfa meal	17% protein, dehydrated, grease treated, 100,000 IU vitamin A activity per pound
Corn gluten meal	60% protein, high in xanthrophyll
Soybean oil meal	50% protein, dehulled, solvent extracted
Peanut meal	50% protein, dehulled, solvent extracted
DL-methionine	98%
Lysine supplement	50% L-lysine
Limestone	Approximately 38% calcium
Rock phosphate, defluorinated	18% phosphorous, 30-36 % calcium, and maximum 0.18% fluorine
Manganese sulphate, feed grade	75% anhydrous $MnSO_4$
Coccidiostat	Amprol Plus (a product of Merk and Co., Inc., Rahway, New Jersey), contained 25% amprolium and 0.8% ethopabate
Animal fat, fancy bleachable	stabilized
Peanut oil	Refined, antioxidant

TABLE II

VITAMIN PREMIX

Ingredients	Pounds
Vitamin D supplement (30,000 I.C.U./g)	0.30
Vitamin A supplement (30,000 I.U./g)	1.67
Riboflavin supplement (20 g./lb.)	1.29
Vitamin B_{12} supplement (20 mg./lb.)	3.00
Aureomycin supplement (10 g./lb.)	6.50
Choline chloride (25%)	22.50
Niacin (50%)	1.00
D-Calcium pantothenate (32 g./lb.)	1.25
Soybean oil meal	34.49
Total	72.00

Calculated analysis for amounts used in diets:

Amount Used, Pounds	0.6
Vitamin D, I.C.U.	34,000.00
Vitamin A, I.U.	189,167.00
Riboflavin, mg.	215.00
Vitamin B_{12}, mg.	0.498
Choline, mg.	18,420.00
Niacin, mg.	1,828.00
Pantothenic acid, mg.	318.00
Aureomycin, mg.	540.00

TABLE III

COMPOSITION OF DIETS BY WEIGHT

Ingredients	Starter Diets			Finisher Diets		
	BR5	BR45	BR46	BF7	BF12	BF13
	Pounds					
1. Yellow corn	53.05	51.95	51.95	53.05	51.95	51.95
2. Alfalfa meal	2.50	2.50	2.50	2.50	2.50	2.50
3. Fish meal anchovie	5.00	5.00	5.00	5.00	5.00	5.00
4. Soybean oil meal	30.00	----	----	30.00	----	----
5. Corn gluten meal	3.00	3.00	3.00	3.00	3.00	3.00
6. Animal fat	3.00	3.00	----	13.00	13.00	----
7. Ground limestone	1.20	1.20	1.20	1.20	1.20	1.20
8. Defl. rock phosphate	1.00	1.00	1.00	1.00	1.00	1.00
9. Salt	0.48	0.48	0.48	0.48	0.48	0.48
10. Manganese Sulfate	0.02	0.02	0.02	0.02	0.02	0.02
11. Vitamin mix	0.6	0.6	0.6	0.6	0.6	0.6
12. Coccidiostat	0.05	0.05	0.05	0.05	0.05	0.05
13. DL-methionine	0.10	0.40	0.40	0.10	0.40	0.40
14. L-lysine	----	0.80	0.80	----	0.80	0.80
15. Peanut meal, 50%	----	30.00	30.00	----	30.00	30.00
16. Peanut oil	----	----	3.00	----	----	13.00
Totals	100.00	100.00	100.00	110.00	110.00	110.00
Calculated and determined analysis:						
Crude Protein, % calculated	25.3	25.9	25.9	23.0	23.5	23.5
Crude Protein, % determined	25.4	26.0	26.0	23.2	23.6	23.6
Productive energy Cal./lb. calculated	1014.0	1007.0	1007.0	1185.0	1179.0	1179.0
C:P ratio	40.08	38.88	38.88	51.52	50.08	50.08
methionine, % calculated	0.51	0.80	0.80	0.46	0.72	0.72
Lysine, % calculated	1.44	1.32	1.32	1.31	1.20	1.20

designated as BF13 (Table III).

All the diets were in all-mash form. BR5, BR45, and BR46 were fed for 8 weeks. These constituted the first three treatments. BR5 was fed for the first five weeks followed by finisher diet BF7 to 8 weeks which constituted the fourth treatment. BR45 was fed for the first five weeks followed by finisher diet BF12 to 8 weeks for the fifth treatment. BR46 was fed for the first five weeks followed by finisher diet BF13 to 8 weeks which was the sixth treatment. A randomized split block design suggested by Snedecor (36) was used with three treatments and four replicates for five weeks study. A design with six treatments and two replicates was used for eight weeks study.

II. GROWTH STUDIES

The experiment was conducted in floor pens of a brooder house containing twelve pens with six pens in a row. Fifty male and fifty female chicks were randomly assigned to the twelve pens. Birds that died during the first week were replaced by birds of the same sex, maintained on a control diet BR5. The chicks were brooded under infra-red lamps. Wood shavings were used as litter. The feed and water were made available at all times. The feeders and waterers were changed to meet the needs of the growing birds.

At the end of five and eight weeks, the birds were weighed and weights were recorded for each individual. The weight of feed which was consumed by the chicks in each pen was calculated after five and eight

weeks and recorded.

Growth and feed efficiency data were analyzed according to an analysis of variance suggested by Snedecor (36). Significance of the differences between treatment means was determined by Duncan's Multiple Range Test (13).

III. PROCESSING, PACKAGING, AND STORAGE OF BIRDS

Fifteen males and fifteen females from each pen were eviscerated by a commercial method and ice-chilled overnight. Each bird was packaged in an evacuated polyethylene bag. The wrapped birds were frozen in an air-blast freezer at -20°F, and were stored at 10°F until used.

IV. COLLECTION AND STORAGE OF FAT

During dressing, visceral fat tissues were collected for each sex from each pen. The fat samples were frozen in an air-blast freezer at -20°F and were freeze-dried. The freeze drying unit was controlled thermostatically at 90°F, and when drying was complete, the vacuum was released by nitrogen gas. The fat was extracted by grinding the freeze-dried tissues with sand (chemical grade) and pressing in hand in between sterilized cotton pads. The extracted fat samples were collected and stored in four ounce jars at 10°F for chemical analysis.

V. TASTE PANEL STUDIES

The carcasses were roasted in an electric despatch oven until the internal temperature of the inner thigh muscle had reached 90°C. The light and dark meat were served separately to the taste panel. Differences in color, flavor, and tenderness of the meat from the following combinations were determined by triangle taste test (33):

1. BR5 and BR45
2. BR5-BF7 and BF12
3. BR45 and BR46
4. BR45-BF12 and BF46-BF13
5. BR46 and BR46-BF13

All the combinations were served at two different settings. Significance of the differences between treatment means were determined by referring to the table of probabilities (33):

VI. COOKING LOSSES

The percentage of evaporation, drip, and total cooking loss were determined and analysed according to an analysis of variance suggested by Snedecor (36). Significance of the differences between treatment means were determined by the Duncan's Multiple Range Test (13).

VII. PHYSICO-CHEMICAL METHODS

Representative samples of feed were collected and analysed for crude protein content. Samples of animal fat and peanut oil were collected and analysed along with the body fat samples.

Per Cent Nitrogen and Crude Protein (Kjeldahl Method). Basically the method (29) converts nitrogen to ammonium sulfate during the digestion process with concentrated sulfuric acid. The ammonium sulfate was treated with strong base and heated to distill ammonia which was collected in boric acid solution. The boric acid solution with the ammonia was treated with standard acid and the per cent nitrogen was calculated from the titration data as indicated below. The per cent nitrogen was related to the per cent protein by a conversion factor.

$$\text{Per cent Nitrogen} = \frac{\text{ml. HCl} \times \text{N. HCl} \times (\text{milleq. wt. of N}) \times 100}{\text{Sample Weight}} \quad (1)$$

Per cent Protein = Average per cent nitrogen x 6.25

Melting Point. Capillary tube method was used (29) for the determination of melting point. The temperature at which fat became transparent was taken as the melting point.

Iodine Number. Hanus method (29) for determination of iodine number was used. An accurately weighed amount of sample (ca. 0.5 gm.) was dissolved in 10 ml. of chloroform, and an excess of iodine was added (25 ml. of iodobromide solution). The flasks were allowed to stand in the dark for 30 minutes. The amount of unreacted iodine was then determined by titration with a standard solution of sodium thiosulfate using a starch indicator. A blank determination was run (in triplicate) along with the samples to measure the amount of iodine present. The number of grams of iodine that reacted with 100 grams of the sample was calculated as follows:

$$\frac{(\text{Blank tit.} - \text{Sample tit.}) \times \text{N. } Na_2S_2O_3 \times \text{Milleq. Wt. } I_2 \times 100}{\text{Sample Weight}} \quad (3)$$

Peroxide Value. The estimation of peroxides was based primarily on their ability to liberate iodine from potassium iodide in chloroform-glacial acetic acid mixture. The peroxide values of the samples were a measure of the reactive oxygen they contained expressed in milliequivalents of oxygen per 1,000 grams of fat or as millimoles of peroxide per kilogram of sample. The Wheeler method (45) was used in measuring the peroxide value. The peroxide value of fat was calculated as follows:

$$\frac{\text{Sample titration} \times \text{N. of } Na_2S_2O_3 \times 1{,}000}{\text{Sample Weight in grams}} \quad (4)$$

Saponification Number. An accurately (ca. 2.0 gms.) weighed sample of fat was refluxed with a measured excess of 0.5 normal alcholic potassium hydroxide solution (25 ml.) to undergo saponification (29) The amount of the alcholic potassium hydroxide which did not react with the sample was determined by titration with standard hydrochloric acid (0.5 N). A blank determination was run with the samples in triplicate to determine the original concentration of KOH. The number of milligrams of potassium hydroxide required to saponify a one-gram sample was calculated as follows:

$$\text{Sap \#} = \frac{(\text{Av. Bk. tit.} - \text{Sample tit.}) \times \text{N. HCl} \times (\text{Milleq. Wt. KOH})}{\text{Sample Weight in grams}} \quad (5)$$

CHAPTER IV

RESULTS AND DISCUSSION

I. GROWTH RATE AND FEED CONVERSION RATIOS

Unfortunately, during the seventh week of age, the birds were attacked by a disease, Avian nephritis-nephrosis (gumboro). Gumboro is caused by a virus-like agent. It is characterized by a slight nervousness at the outset, loss of appetite and activity, ruffled feathers, elevated temperatures, watery diarrhea, difficulty in defecating, unsteady gait, dehydration, prostration and death (1). Mortality was checked within three days by adequate doses of aureomycin in the drinking water. Though the spread of the disease was curtailed during the above period, some undesirable effects and after-effects on growth rate and efficiency of feed utilization would be anticipated. Growth rate data were thought to be within expected limits. However, the disease apparently skewed the feed efficiency data. They were rather unexpectedly poor and inconsistent. Therefore, feed efficiency calculations will be indicated only for the first five weeks of the growth trial. It was considered that the disease had no effect upon the characteristics of the carcass fat although no study could be made of this problem. Average body weights of the birds at five weeks of age are shown in Table IV. No significant differences were observed for the average body weight of the birds fed the above three diets. However, a significantly better growth in male birds

TABLE IV

AVERAGE BODY WEIGHTS AND FEED CONVERSION RATIOS
OF BIRDS AT FIVE WEEKS OF AGE.

Protein Source	Fat Source	Male	Female	Average	Feed/Weight
		Grams			
Soybean oil meal	Animal fat	812	693	753	1.9301
Peanut meal	Animal fat	797	695	746	1.9251
Peanut meal	Peanut oil	780	702	741	1.9096

than in female birds was observed, irrespective of the diet treatment. Among the males, the birds that were fed the soybean oil meal-animal fat diet, gained slightly more weight than the birds that were fed the peanut meal-animal fat and peanut meal-peanut oil diets.

No significant differences were observed for average body weights of birds at eight weeks of age (Table V). However, a significantly better growth of males than of female birds was observed, irrespective of the diet treatments. The birds that were fed finisher diets had slightly better growth than the ones that were fed starter diets. Considering the starter diet treatments only, soybean oil meal-animal fat diet gave a better growth to male birds than the peanut-meal-animal fat and peanut meal-peanut oil diets. Similar observations for the effect of protein-fat sources on growth were observed for male birds that were fed the finisher diets.

Gain in weight by the birds from five to eight weeks of age is shown in Table VI. No significant differences for average weight gains were observed. Male birds had significantly better weight gains than the female birds. Finisher diet treatments appeared to support better growth in chicks than the starter diet treatments: however, they were not significantly different.

The results show that soybean oil meal as a major source of protein supported better growth in chicks compared to methionine-lysine supplemented peanut meal. The findings of Rose (34) and Waldrop and Harms (43) show similar results.

TABLE V

AVERAGE BODY WEIGHTS OF BIRDS AT EIGHT WEEKS OF AGE

Protein Source	Fat Source	Type of Diet 6-8 Weeks	Male	Female	Average
			Grams		
Soybean oil meal	Animal fat	Starter	1773	1438	1606
Soybean oil meal	Animal fat	Finisher	1845	1505	1675
Peanut meal	Animal fat	Starter	1756	1460	1608
Peanut meal	Animal fat	Finisher	1804	1504	1654
Peanut meal	Peanut oil	Starter	1725	1455	1590
Peanut meal	Peanut oil	Finisher	1776	1505	1691

TABLE VI

AVERAGE INCREASE IN BODY WEIGHTS OF BIRDS
BETWEEN FIVE AND EIGHT WEEKS OF AGE

Protein Source	Fat Source	Type of Diet 6-8 Weeks	Male	Female	Average
			Grams		
Soybean oil meal	Animal fat	Starter	951	741	846
Soybean oil meal	Animal fat	Finisher	1043	816	930
Peanut meal	Animal fat	Starter	956	766	861
Peanut meal	Animal fat	Finisher	1013	808	911
Peanut meal	Peanut oil	Starter	942	751	847
Peanut meal	Peanut oil	Finisher	999	806	903

Increase in caloric density at an adequate protein level (23 to 25 per cent) has been shown to give better growth to chicks (4), (35), and (42). The experiments in this study show similar results.

Lower growth rate of birds that were peanut oil than the ones that were fed animal fat did give an inference that animal fat had a better effect on growth rate than vegetable fat. Leveille and Fisher (28) have shown similar results.

The feed conversion ratios for a five week period (Table IV, p. 22) showed no significant difference among the diet treatments. However, the birds that were fed peanut oil showed slightly better feed conversion ratios than the birds that were fed animal fat. Better feed utilization by birds fed unsaturated fatty acids than the ones fed saturated fatty acids has been shown by Sunde (40).

II. ORGANOLEPTIC EVALUATION

Flavor. The source of fat has been thought to give a characteristic flavor to the cooked meat (14, 25). By a triangle taste test, no significance for the differences of the treatment values for flavor were observed.

Tenderness. No significant differences between treatment values for tenderness were observed. Arscott and Sather (3) and experiments by Dawson and Essary (10) showed similar results.

Color. In triangle test combinations, variation in protein source (BR5 and BR45, BR5-BF7, and BR45-BF12) as well as fat source (BR45 and

BR46) at normal or high level of fat (BR45-BF12 and BR46-BF13), showed a highly significant difference between the treatment values for color of light as well as dark meat (Table VII and VIII). Table IX shows the performance by individual panelists in detecting the odd sample in triangular tests. They expressed themselves correct at a high level of confidence.

III. COOKING LOSSES

Evaporation loss and dripping loss during roasting are given in Table X. No significant differences were observed among the treatments means for either evaporation loss or dripping loss. The results support the findings of Arscott and Sather (3) and Stephens et al. (38).

IV. CHEMICAL CHARACTERISTICS OF DIETARY AND CARCASS FAT

Melting point. The melting point of a fat reflects its fatty acid composition. Though the exact fatty acids composition was not determined, there appears to be a resemblance between dietary and carcass fat (Table XI). The body fat of birds fed animal fat had melting points (101.0, 96.5°F) resembling that of animal fat (85.5°F). Similarly, the body fat of birds fed peanut oil had a melting point (64.0°F) resembling the peanut oil (53.5°F). The body fat of birds fed higher percentages of peanut oil resembled more closely than the ones fed lower percentages of fat. No such effect was observed for the body fat of birds fed animal fat. No difference was observed between the mean values of sexes.

TABLE VII

TRIANGLE TEST RESULTS FOR COLOR OF LIGHT MEAT

Diet Combination	No. of Testers	Correct Answers	Significance Level (33)	Total No. Testers	Correct Answers	Significance Level (33)
BR5	8	6	N.S.	18	16	0.001
and BR45	10	10	0.001			
BR5-BF7	8	3	N.S.	18	12	0.01
and BR45-BF12	10	9	0.001			
BR45	8	7	0.001	15	14	0.001
and BR46	7	7	0.001			
BR45-BF12	9	8	0.001	18	14	0.01
and BR46-BF13	9	6	0.01			
BR46	8	4	N.S.	16	9	N.S.
and BR46-BF13	8	5	N.S.			

TABLE VIII

TRIANGLE TEST FOR COLOR OF DARK MEAT

Diet Combination	No. of Testers	Correct Answers	Significance Level (33)	Total No. Testers	Correct Answers	Significance Level (33)
BR5	8	8	.001			
and BR45	10	5	N.S.	18	13	.001
BR5-BF7	8	7	.01			
and BR45-BF12	10	10	.001	18	17	.001
BR45	8	7	.01			
and BR46	7	6	.01	15	13	.001
BR45-BF12	9	8	.001			
and BR46-BF13	9	7	.01	18	15	.001
BR46	8	6	.05			
and BR46-BF13	8	2	N.S.	16	8	N.S.

TABLE IX

PERFORMANCE OF INDIVIDUAL PANELISTS FOR COLOR OF LIGHT AND DARK MEAT BY TRIANGLE TASTE TESTS

Panelist	No. of Tests	Correct Answers	Significance Level (33)	Total No. Tests	Correct Answers	Significance Level (33)
1	8	6	.05			
	8	7	.01	16	13	.001
2	8	4	N.S.			
	8	8	.001	16	12	.001
3	8	7	.01			
	8	6	.05	16	13	.001
4	8	8	.001			
	8	5	N.S.	16	13	.001
5	8	6	.05			
	8	8	.001	16	14	.001
6	8	7	.01			
	8=	3	N.S.	16	10	.05
7	8	6	.05			
	8	4	N.S.	16	10	.05

TABLE X

AVERAGE VALUES OF COOKING LOSSES OF BROILERS DURING ROASTING

Protein Source	Fat Source	Type of Diet 6-8 Weeks	No. Birds Used	Evaporation Loss, %	Drip Loss, %	Total Loss, %
Soybean oil meal	Animal fat	Starter	4	17.85	7.43	25.28
Soybean oil meal	Animal fat	Finisher	4	18.93	6.53	25.46
Peanut meal	Animal fat	Starter	8	17.58	6.40	23.98
Peanut meal	Animal fat	Finisher	8	17.99	7.29	25.28
Peanut meal	Peanut oil	Starter	8	17.40	6.54	23.94
Peanut meal	Peanut oil	Finisher	8	17.16	8.21	25.37

TABLE XI

MELTING POINT (°F) OF VISCERAL FAT AND SUPPLEMENTARY DIET FAT

Protein Source	Fat Source	Type of Diet 6-8 Weeks	Male	Female	Average Value of Sexes
Soybean oil meal	Animal fat	Starter	100.5	100.5	
			101.5	101.5	
		Average	101.0	101.0	101.0[a]
Soybean oil meal	Animal fat	Finisher	100.0	100.0	
			100.0	100.0	
		Average	100.0	100.0	100.0[a]
Peanut meal	Animal fat	Starter	96.5	96.5	
			96.5	96.5	
		Average	96.5	96.5	96.5[b]
Peanut meal	Animal fat	Finisher	100.0	100.0	
			100.0	100.0	
		Average	100.0	100.0	100.0[a]
Peanut meal	Peanut oil	Starter	64.0	64.0	
			63.5	64.0	
		Average	63.8	64.0	63.9[c]
Peanut meal	Peanut oil	Finisher	57.5	57.0	
			58.5	58.0	
		Average	58.0	57.5	57.8[d]

Animal fat 85.5°F
Peanut oil 53.5°F

* Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test(13).

Saponification Value. Saponification value (Table XII) of animal fat (199.96) was slightly higher than that of peanut oil (186.96). Though the differences between mean values of carcass fats were significant, they did reflect the effect of dietary fat. The body fat of birds fed animal fat as a dietary fat had a saponification value of 193.50. This was slightly higher than that (190.43) of birds fed peanut oil as a dietary fat.

Peroxide Value. The peroxide values of dietary fats (Table XIII) were low as they were stabilized by antioxidants. Peanut oil has a slightly higher peroxide value than animal fat. Differences between the mean peroxide values of the body fat of birds fed peanut oil were significantly higher than the body fat of birds fed animal fat.

Iodine Number. Iodine numbers of dietary and carcass fats are shown in Table XIV. Animal fat is a highly saturated fat. Peanut oil is fairly unsaturated. It was observed that the iodine numbers of carcass fats tend to resemble dietary fats. With iodine value as a measuring rule, Cruickshank (8), Fingenbaum and Fisher (16), Machlin et al. (22), and Mickelberry et al. (26) deduced that the dietary fat can alter the body fat composition in the direction of greater saturation or unsaturation. Similar results have been shown by Daghir et al. (9) and Marion et al. (23) by use of gas-liquid chromatography analysis.

For animal fat fed birds, slightly higher iodine values for carcass fat were observed than for dietary fat. This could be explained by the

TABLE XII

SAPONIFICATION NUMBER OF VISCERAL FAT AND SUPPLEMENTARY DIET FAT

Protein Source	Fat Source	Type of Diet 6-8 Weeks	Male	Female	Average Value of Sexes
Soybean oil meal	Animal fat	Starter	190.35	192.08	
			194.08	194.51	
		Average	192.22	193.30	192.76
Soybean oil meal	Animal fat	Finisher	194.53	194.53	
			196.01	195.43	
		Average	195.01	194.98	194.98
Peanut meal	Animal fat	Starter	193.89	194.13	
			193.11	197.16	
		Average	193.50	195.65	194.58
Peanut meal	Animal fat	Finisher	193.65	194.60	
			193.64	194.74	
		Average	193.65	194.67	194.34
Peanut meal	Peanut oil	Starter	192.97	190.40	
			187.89	193.04	
		Average	190.43	191.72	191.03
Peanut meal	Peanut oil	Finisher	191.03	191.30	
			191.01	191.37	
		Average	191.02	191.34	191.18

Animal fat 199.96
Peanut oil 186.28

TABLE XIII

PEROXIDE NUMBER OF VISCERAL FAT AND SUPPLEMENTARY DIET FAT

Protein Source	Fat Source	Type of Diet 6-8 Weeks	Male	Female	Average Value of Sexes
Soybean oil meal	Animal fat	Starter	1.385	1.345	
			1.350	1.375	
		Average	1.367	1.360	1.364[a]
Soybean oil meal	Animal fat	Finisher	1.325	1.325	
			1.395	1.485	
		Average	1.360	1.405	1.383[a]
Peanut meal	Animal fat	Starter	1.635	1.580	
			1.400	1.420	
		Average	1.518	1.500	1.509[a]
Peanut meal	Animal fat	Finisher	1.480	1.390	
			1.425	1.375	
		Average	1.453	1.383	1.418[a]
Peanut meal	Peanut oil	Starter	2.065	1.700	
			2.080	2.025	
		Average	2.073	1.863	1.978[b]
Peanut meal	Peanut oil	Finisher	2.105	1.760	
			2.045	2.125	
		Average	2.075	1.943	2.009[b]

Animal fat 1.462
Peanut oil 1.830

* Means with different superscripts are significantly different at the 5% level of probability as calculated by Duncan's Multiple Range Test (13).

TABLE XIV

IODINE NUMBER OF VISCERAL FAT AND SUPPLEMENTARY DIET FAT

Protein Source	Fat Source	Type of Diet 6-8 Weeks	Male	Female	Average Value of Sexes
Soybean oil meal	Animal fat	Starter	60.972	62.920	
			61.157	62.812	
		Average	61.650	62.866	61.965[a]
Soybean oil meal	Animal fat	Finisher	59.762	60.621	
			58.384	58.347	
		Average	59.065	59.484	59.274[b]
Peanut meal	Animal fat	Starter	60.222	60.524	
			61.187	60.143	
		Average	60.704	60.334	60.334[ab]
Peanut meal	Animal fat	Finisher	59.744	55.386	
			55.877	55.884	
		Average	57.810	55.635	56.722[c]
Peanut meal	Peanut oil	Starter	68.885	66.174	
			71.501	70.725	
		Average	70.193	68.449	69.321[d]
Peanut meal	Peanut oil	Finisher	76.334	75.303	
			77.084	76.611	
		Average	76.704	75.957	76.330[c]

Fancy Bleachable Fat 43.907
Peanut Oil 77.970

* Means with different superscripts are significantly different at the 1% level of probability as calculated by Duncan's Multiple Range Test(13).

formation of polyunsaturated acids from saturated acids (31) and (22).

For peanut oil fed birds, the values for carcass fat were lower than the peanut oil. Peanut oil contains oleic acid (18:1) 53 per cent, and 27 per cent linoleic (18:2) acid (18). The major changes in the oleic and linoleic acid fractions were observed in body fats by Fingenbaum and Fisher (16). They found that oleic acid was increased and the linoleic acid was decreased. A slight change in the above two major fatty acid components of peanut oil could be responsible for a lower iodine value of body fat.

SUMMARY

A total of 1200 cross-bred (Vantress x Arbor Acre 50) broiler type chicks were used to study the effect of peanut meal (50 per cent) and peanut oil in broiler diets on growth, feed efficiency, characteristics of deposited fat, and organoleptic characteristics of roasted light and dark meat.

During the seventh week of age, the birds were attacked by a disease, Avian nephritis-nephrosis (gumboro). Though the growth data were thought to be within expected limits, the disease apparently skewed the feed efficiency data. They were rather unexpectedly poor and inconsistent.

Under conditions of the experiments reported in this paper it was found that:

1. No significant differences were observed for average body weights of birds at five and eight weeks of age. However, a significantly better growth in male than in female birds was observed, irrespective of diet treatments. Finisher diet treatments appeared to support better growth in chicks than the starter diet, but the differences were not significant. Soybean oil meal as a major source of protein appeared to support better growth in chicks than methionine-lysine supplemented peanut meal, but the differences were not significant. At five weeks of age the birds that were fed peanut oil showed slightly better feed conversion ratios than the birds that were fed animal fat, but the difference was not significant.

2. No significant differences between treatment values for flavor and tenderness of either roasted light or dark meat were observed by triangle taste tests. Variation in protein source as well as fat source in the starter or finisher diets showed a highly significant difference in color of light as well as dark meat. The panelists chose the odd sample correctly at a high level of confidence. No significant differences were observed among the treatment means for either evaporation loss or dripping loss.

3. Dietary fat affected the characteristics of the body fat as measured by melting point, saponification number, peroxide value, and iodine number.

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APPENDIX

TABLE XV

AVERAGE WEIGHTS OF MALE BIRDS AT FIVE WEEKS OF AGE

Treatment No.	Pen No.	No. Birds per Pen	Av. Wts. (grams)
1	2	48	804.5
1	3	46	822.3
1	9	41	799.2
1	12	43	820.6
2	4	48	777.2
2	5	47	803.8
2	7	48	799.9
2	11	49	805.5
3	1	49	779.3
3	6	45	778.9
3	8	45	777.9
3	10	49	775.5

TABLE XVI

AVERAGE WEIGHTS OF FEMALE BIRDS AT FIVE WEEKS OF AGE

Treatment No.	Pen No.	No. Birds per Pen	Av. Wts. (grams)
1	2	48	689.3
1	3	54	702.5
1	9	56	687.6
1	12	54	691.4
2	4	48	700.2
2	5	50	688.9
2	7	51	700.1
2	11	48	691.6
3	1	51	713.7
3	6	50	688.9
3	8	52	718.2
3	10	48	686.4

TABLE XVII

AVERAGE WEIGHTS OF MALE BIRDS AT EIGHT WEEKS OF AGE

Treatment No.	Pen No.	No. of Birds per Pen	Av. Wts. (grams)
1	3	43	1795.1
1	12	40	1750.5
2	5	37	1737.0
2	7	47	1775.3
3	6	43	1726.9
3	8	39	1723.8
4	2	44	1846.7
4	9	37	1842.7
5	4	44	1770.4
5	11	43	1837.4
6	1	48	1777.5
6	10	42	1774.7

TABLE XVIII

AVERAGE WEIGHTS OF FEMALE BIRDS AT EIGHT WEEKS OF AGE

Treatment No.	Pen No.	No. of Birds per Pen	Av. Wts. (grams)
1	3	52	1474.8
1	12	50	1401.0
2	5	46	1431.7
2	7	50	1489.7
3	6	47	1435.3
3	8	50	1473.8
4	2	47	1507.0
4	9	56	1501.0
5	4	46	1496.9
5	11	43	1510.4
6	1	48	1520.0
6	10	47	1490.0

TABLE XIX

FEED CONVERSION RATIOS AT FIVE WEEKS OF AGE

Treatment No.	Pen No.	Feed/Weight
1	2	1.8823
1	3	1.8535
1	9	2.0882
1	12	1.8960
2	4	1.9251
2	5	1.9474
2	7	1.8806
2	11	1.9469
3	1	1.8432
3	6	1.9655
3	8	1.8860
3	10	1.9435

TABLE XX

FEED CONVERSION RATIOS AT EIGHT WEEKS OF AGE

Treatment No.	Pen No.	Feed/Weight
1	3	2.3270
1	12	2.4217
2	5	2.5430
2	7	2.2566
3	6	2.4142
3	8	2.3954
4	2	2.1983
4	9	2.6241
5	11	2.3208
6	1	2.1317
6	10	2.2706

During the seventh week of age the birds were attacked by a disease, Avian nephritis-nephrosis (gumboro).

VITA

The author was born on December 13, 1939, in Surat, India. He received his B.S., with a major in Chemistry, from Wilson College, University of Bombay, India, in 1960. In 1962 he received an associateship diploma in Food Technology from Central Food Technological Research Institute, Mysore, India. In 1964 he came to the University of Tennessee, Knoxville, Tennessee, and worked for his M.S. in Food Technology.