THE EFFECTS OF DIETARY PROTEIN LEVELS ON THE CARCASS COMPOSITION OF STARTER AND GROWER BROILERS

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Summary

Carcass analysis of most economical parts of broilers were studied after they were fed with different protein levels of 16, 18, 20 and 23% for the starter period and 16, 18 and 20% for the grower period. The energy value of the feed was constant at 3,200 kcal ME/kg. The results for the starter and grower broilers showed similar pattern of responses. There were significant increased in weight gain, feed intake, protein intake, while there were significant decrease in the feed conversion ratio (FCR), abdominal fat and carcass fat when dietary protein increased. For the economical parts of the carcass, most of the fats were found in the thigh meat, while the lowest was found in the breast meat. The protein levels did not influence the meat production of the breast, drumstick and thigh portion. Increasing the protein intake, increased the broiler performance in relation to increased protein content of the breast, drumstick and thigh meat. The different fat contents of the meat might be due to differences in the rate of lipogenesis and fat deposition of the meat.
(**Key Words** : Dietary Protein, Carcass Composition, Starter and Grower Broilers)

Introduction

Within the normal range of dietary protein contents, voluntary intake is not affected by the protein content of the diet. Intake is, however, depressed by diets of lower protein concentration and the lower critical content of protein in a feed is determined as that level below which voluntary intake is depressed (Forbes, 1986). Boorman (1979), reviewed the effects of protein content on the voluntary intake of laying hens and showed that although there were some compensation of the intake for a diet of a low protein concentration, it might not be enough to maintain a constant protein intake. In studies with growing chicks, Hill and Dansky (1954) found no effect on feed intake or growth rate on diets of various protein levels. However, Uzu (1982) found that decreasing the protein content from 20 to 16% in the diet of broilers resulted in an increase in feed consumption. The high environmental temperature did not affect the feed intake and growth rate if the protein levels were increased while the energy level remained constant (Sinurat and Balnave, 1985). Similar findings were made by Fancher and Jensen (1989) who found that feed intake was not affected by the isocaloric diets.

Excessive fat in broilers has become a problem of worldwide concern and it is of importance to study the various aspects of the problem. Broilers have major fat depots located in the abdominal region, within the thigh muscles and in and under the skin (Moran, 1988) and the excessive fat is associated with a waste of dietary energy. Abdominal fat is the most prominent in decreasing carcass quality because of its high visibility. The abdominal and subcutaneous depots maximize their growth rate during the first several weeks of life while the thigh and cutaneous depots developed later. Obesity in chicken is influenced by genetic, environmental, physiological and nutritional factors. Energy and protein levels, specific amino acids, dietary fat and feeding regime are more important nutritional factors (McLeod, 1982). The present studies were aimed at evaluating different parts of the carcass when the broilers were fed different levels of protein in isocaloric diets.

Materials and Methods

Starter Period (0-3 weeks)

Animals and general procedures

One hundred and forty-four male day-old ISA Vadette broiler chicks were randomly distributed into 4 groups of

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12 chicks each on the basis of similar group weight. The chicks were reared in raised wire floor cages, and they were brooded accordingly. Four diets of different levels of protein were fed seperately to each experimental group with three replications each. Feed and water were given *ad libitum.* Body weight and feed intake were recorded weekly from each cage while mortality and ambient temperature (23-37℃) were recorded daily and feed consumption was adjusted to account for mortality.

Diets

Four diets, comprised mainly of corn and soybean meal were formulated to be isocaloric at 3,200 kcal ME/kg, with protein levels of 16, 18, 20 and 23% were fed in mash form to the chicks from day-old until three weeks. The composition of the diets are shown in table 1. The amount of corn soybean meal were adjusted to achieve the protein levels while commercial DL-methionine and L-lysine were added to a specified levels of recommendation (NRC, 1984).

TABLE 1. COMPOSITION OF STARTER DIETS

Ingredients (%)	Crude protein (%)			
	16	18	20	23
Ground yellow corn	54.70	51.20	47.70	42.50
Soybean meal (44%)	25.50	30.70	36.00	43.77
Palm oil	9.64	9.64	9.64	9.64
Premix (Vitamins & minerals)[1]	0.25	0.25	0.25	0.25
Salt	0.50	0.50	0.50	0.50
Coccidiostat	0.05	0.05	0.05	0.05
Limestone	1.50	1.42	1.42	1.41
Dicalcium phosphate	1.80	1.72	1.64	1.55
DL-methionine	0.30	0.24	0.18	0.09
L-lysine	0.32	0.18	0.03	—
Kaolin clay	5.44	4.10	2.59	0.24
Total	100.00	100.00	100.00	100.00
Calculated analysis:				
Protein (%)	16.03	18.01	20.04	23.00
ME (kcal/kg)	3,201	3,200	3,201	3,200
Calcium (%)	1.03	1.00	1.00	1.00
Available phosphorus (%)	0.46	0.45	0.45	0.45
TSAA (%)	0.83	0.83	0.83	0.83

[1] Vitamin & mineral premix contain the following per kg diet.
Vit. A 10,000 IU, D_3 2,000 IU, E 15 IU, K_3 1.5 mg, B_1 1.5 mg, B_2 5 mg, B_6 2 mg, B_{12} 10 μg, Pantothenic acid 12 mg, Biotin 10 μg, Niacin 25 mg, Choline Chloride 900 mg, Folic acid 0.5 mg, Cu 10 mg, Mn 52.5 mg, Zn 60 mg, Fe 100 mg, I 1.5 mg, Co 0.25 mg.

Grower Period (4-6 weeks)

Animals and general procedures

The experiment was conducted using commercial ISA Vadette male broiler chickens. For the initial 3 weeks, all chicks were reared together on deep litter system and fed a standard commercial diet containing 3,100 kcal ME/kg and 23% crude protein. At 3 weeks of age, the birds were weighed and randomly assigned to treatment in such a way that the average starting weight was similar for each replicate. The chickens were reared in raised floor cages and each treatment was applied to the three replicates of 12 birds each. All birds received the three experimental feeds and water *ad libitum* and were subjected to continuous lighting until 6 weeks of age. Body weight and feed intake were recorded at 28, 35 and 42 days of age. Mortality and ambient temperature (23-37℃) were recorded daily and the feed consumption was adjusted to account for mortality.

Diets

Diets, formulated encompassing three levels of crude protein (16, 18 and 20%) at 3,200 kcal ME/kg, were offered in mash form as shown in table 2. DL-methionine and L-lysine were added to provide adequate amino acids as recommended by NRC (1984).

Slaughtering procedure and carcass sectioning

Starter period

At the end of the experiment, 5 birds per replicate were randomly selected, fasted for 12 hours, weighed and slaughtered. After scalding the carcass were defeathered in a drum type defeathering machine after which the head and the feet were removed. The carcasses were eviscerated and frozen in shrinkable plastic bags for subsequent dissection. Before the commencement of analysis each carcass was thawed at room temperature and free fluid was drained off. The eviscerated carcass weight was obtained to calculate the dressing percentage. The abdominal fat was then removed and weighed according to the procedure of Kubena et al. (1974), as a pecrentage of live body weight. Fat surrounding the gizzard and intestines extending within the ischium and surrounding the Bursa of Fabricius were considered as abdominal fat. The carcasses were sectioned into breast, drumstick and thigh portions. Bones were removed from each cut and the meat (without the skin) were then frozen at −22℃ to await analysis for moisture, protein and fat content.

TABLE 2. COMPOSITION OF GROWER DIETS

Ingredients (%)	Crude protein (%)		
	16	18	20
Ground yellow corn	54.70	51.20	47.70
Soybean meal (44%)	25.50	30.70	36.00
Palm oil	9.64	9.64	9.64
Premix (Vitamins & minerals)[1]	0.25	0.25	0.25
Salt	0.50	0.50	0.50
Coccidiostat	0.05	0.05	0.05
Limestone	1.32	1.30	1.30
Dicalcium phosphate	1.48	1.45	1.38
DL-methionine	0.19	0.13	0.07
L-lysine	0.12	–	–
Kaolin clay	6.25	4.78	3.11
Total	100.00	100.00	100.00
Calculated analysis:			
Protein (%)	16.03	18.01	20.04
ME (kcal/kg)	3,201	3,200	3,201
Available phsophours (%)	0.40	0.40	0.40
Lysine (%)	1.00	1.02	1.17
TSAA (%)	0.72	0.72	0.72

[1] Vitamin & mineral premix contain the following per kg diet. Vit. A 10,000 IU, D_3 2,000 IU, E 15 IU, K_3 1.5 mg, B_1 1.5 mg, B_2 5 mg, B_6 2 mg, B_{12} 10 μg, Pantothenic acid 12 mg, Biotin 10 μg, Niacin 25 mg, Choline Chloride 900 mg, Folic acid 0.5 mg, Cu 10 mg, Mn 52.5 mg, Zn 60 mg, Fe 100 mg, I 1.5 mg, Co 0.25 mg.

Meat preparation

Meat samples from the same portion within replicate were pooled, chopped and homogenized in a Waring blender before drying in an oven at 60℃ for 72 hours. The dried samples were ground using mortar and pastle, then kept in plastic screw-capped bottles before being analysed.

Proximate analysis

The dry homogenate samples were allowed to equilibrate with atmospheric moisture prior to chemical analysis and air-dry weight was measured. However, because analyses were spread over a period of time, the analyses of every sample was accompanied by a dry matter (DM) measurement (AOAC, 1984) and data were expressed on DM basis. The values for moisture, crude protein, crude fat and fat (according to Folch et al., 1957) were determined according to AOAC (1984).

Grower period

At the termination of the experiment (6 weeks of age), 5 birds per replicate were randomly selected, weighed and slaughtered. Abdominal fat content, total of breast, thigh and drumstick meat from each portion were measured. Protein and fat contents were also determined for the meat.

Four additional birds per replicate were used to determine moisture, protein and fat of the whole birds.

Whole carcass analysis

The preparation technique of dry homogenate from birds were as described in the starter period using the technique developed by Sibbald and Fortin (1982). Proximate analysis of moisture, crude protein and fat content of samples were as described in the starter period.

Statistical analysis

Performance, carcass and tissue composition were analysed using the Statistical Analysis System (SAS, 1982). The significant parameter means were separated using Duncan's new multiple range test (Steel and Torrie, 1980).

Results and Discussion

Starter period

Data on the performance of the main treatment effects are presented in table 3. Significant differences ($p < 0.05$) in body weight gain, feed intake, feed:gain ratio, abdominal fat, protein intake and ME intake were

TABLE 3. PRODUCTION PERFORMANCE OF THE STARTER BROILERS FED ON DIFFERENT DIETARY PROTEIN LEVELS

Crude protein (%)	Weight gain (g/b/d)	Food intake (g/b/d)	FCR	Dressing (%)	Abdominal fat (% BW)	Protein intake (g/b/d)	ME Intake (kcal/b/d)
16	27.79[a]	48.54[a]	1.75[a]	63.05	2.31[a]	7.77[a]	155.33[a]
18	29.77[b]	48.87[a]	1.64[b]	63.38	2.20[a]	8.08[a]	156.39[a]
20	30.89[b]	50.39[b]	1.63[b]	62.87	1.77[b]	10.08[b]	161.24[b]
23	30.60[b]	49.57[b]	1.62[b]	62.94	1.49[c]	11.40[c]	158.63[c]

[abc] Figures with different supercripts in the same column differ significantly ($p < 0.05$).

observed. Birds fed with higher protein diet produced better performance as shown by the lowest feed conversion ratio (FCR) and abdominal fat. Protein and ME intakes were significantly increased for birds fed with higher protein levels of 20 and 23%. On the other hand, there was a significant reduction in abdominal fat for the higher protein diet. There seemed to be a close relationship between fat deposition and the energy:protein ratio. The smaller the ratio, the less fat will be accumulated.

Dietary protein did not significantly affect ($p < 0.05$) the yield of breast meat and thigh meat although the yield of the breast meat and thigh meat showed an increasing trend (table 4). Birds fed with 23% protein produced the highest breast meat yield (10.55% BW) compared to 16% protein (9.75% BW). Significant variations ($p < 0.05$) were observed for the protein and the fat content of the breast, drumstick and thigh meat due to increasing dietary protein levels. The protein contents for the three types of meat increased while the fat contents were similarly decreased with the increasing dietary protein.

The results showed that increasing dietary protein had significant effects on the performances of starter broilers as shown by improvements of body weight gain and feed:gain ratio as similarly shown by Summers and Leeson (1985) and Leeson et al. (1988) and a decreased in abdominal fat (Leeson et al., 1988). Reduction in feed intake was noted for birds fed 16% protein relative to higher protein levels. The voluntary intakes of the birds were affected by the protein levels of the feed. In general, birds fed on higher protein content diets seemed to over consume greater quantities of protein and ME as also shown by Jackson et al. (1982) and Leeson et al. (1988) (table 3).

Although, increasing dietary protein failed to show a significant increase in the yield of breast, drumstick and thigh meat, the yield of these meat showed a trend of increasing value as the dietary protein increased (table 4). Increasing dietary protein resulted in significant differences in protein and fat content of breast, drumstick and thigh meat as similarly shown by Summers et al. (1988), for the increased total percentage of meat resulted in the decreased percentage of fat.

Grower period

The result on grower broiler performance indicated that dietary protein levels significantly influenced body weight gain, feed intake and feed:gain ratio (table 5). Although, FCR of chickens on 18% CP diet was higher than those on 20% CP diet, their body weight gain was similar. These present results showed that CP levels could be reduced approximately 2% below NRC (1984) recommended level of 20% CP for grower broilers without adversely effecting the growth rate of growing broilers. The decreasing dietary protein widened the calorie:protein ratio, resulting in excessive energy intake

TABLE 4. EFFECT OF DIETARY PROTEIN LEVELS ON THE QUALITY OF THE ECONOMICAL MEAT OF STARTER BROILERS

Crude protein %	Breast meat			Drumstick meat			Thigh meat		
	% B.W	Protein (% DM)	Fat (% DM)	% B.W	Protein (% DM)	Fat (% DM)	% B.W	Protein (% DM)	Fat (% DM)
16	9.75	82.49^a	13.29^a	5.64	74.28^a	20.86^a	6.75	50.23^a	45.75^a
18	10.25	82.92^a	14.12^b	5.85	75.23^a	20.07^a	7.41	52.63^b	44.36^a
20	10.32	85.48^b	10.59^c	6.01	77.29^b	17.78^b	7.00	53.37^b	42.72^b
23	10.55	84.95^b	10.50^c	6.05	77.67^b	17.62^b	7.04	58.23^c	37.75^c

[abc] Figures with different superscripts in the same column differ significantly ($p < 0.05$).

TABLE 5. EFFECT OF DIETARY PROTEIN LEVELS ON THE WEIGHT GAIN, FEED INTAKE, PROTEIN AND ME INTAKE OF GROWER BROILERS

Crude protein (%)	Weight gain (g/b/d)	Feed intake (g/b/d)	F.C.R	Protein intake (g/b/d)	ME intake (Kcal/b/d)
16	59.63^a	127.22^a	2.14^a	20.35^a	407.11^a
18	61.21^b	128.01^a	2.09^a	23.04^b	409.64^a
20	62.26^b	123.50^b	1.98^b	24.70^c	395.20^b

[abc] Figures with different supercripts in the same column differ significantly ($p < 0.05$).

as relative to protein intake, thus resulted in high carcass fat content (table 6), as similarly observed by Pfaff and Austic (1976), Griffiths et al. (1977) and Twining et al. (1978).

An attempt to reduce the protein level of the diet would help to reduce feed cost. The results of this study indicated that optimal performance could be achieved by reducing 5% and 2% of dietary protein below the recommended levels for starter and grower diets respectively, provided the amino acids were adequate. By adjusting dietary constituents it was possible to produce broilers with widely varying amount of body fat (Mabray and Waldroup, 1981). The effect of calorie:protein ratio had been demonstrated earlier by others (Bartov et al., 1974; Farell, 1974; Yamashita et al., 1975) which showed that increasing the ratio increased the fat content.

Increasing dietary protein failed to show a significant increase in the yield of breast, drumstick and thigh meat (table 7). However, increasing dietary protein levels affected the protein and fat content of the breast and thigh meat. It should be pointed out that from the present data, increasing dietary protein resulted in the reduction of fat deposition of the tissues as similarly seen in the carcass of the starter period. The thigh meat had the highest fat content, while the breast meat had the lowest fat content as similarly shown by Grey et al. (1983). In birds, the liver is the primary site of fatty acid synthesis (Goodrige and Ball, 1966) with adipose tissue being chiefly a site of lipid storage. However, tissues other than the liver, especially, adipose tissue and skin contributed to fatty acid synthesis. Since the growth of fat in various sites was not synchronous and may be affected by dietary composition, the rate of mobilization and of deposition were not necessarily the same among the various tissues. It should be pointed out that the different fat contents of the meat might be due to the differences in the rate of lipogenesis and fat deposition of the meat.

From this study it was clear that chickens were not able to adjust their energy intake exactly but tend to overconsume more energy in the process of meeting the protein requirement for the tissue built up. An increase in the protein intake subsequently increased performance of the chickens in relation to the increased protein content of the breast, drumstick and thigh meat.

TABLE 6. THE EFFECT OF DIETARY PROTEIN LEVELS ON THE DRESSING PERCENTAGE AND CARCASS VALUE OF GROWER BROILERS

Crude protein (%)	Dressing (%)	Abdominal fat (% BW)	Carcass		
			Moisture (%)	Protein (% DM)	Fat (% DM)
16	67.64	2.48[a]	64.38	48.86[a]	39.01[a]
18	67.98	2.22[a]	65.35	50.42[b]	37.01[b]
20	67.41	1.65[b]	65.35	50.40[b]	36.89[b]

[ab] Figures with different superscripts in the same column differ significantly ($p < 0.05$).

TABLE 7. THE EFFECT OF DIETARY PROTEIN LEVELS ON THE QUALITY OF THE ECONOMICAL MEAT OF GROWER BROILERS

Crude protein %	Breast meat			Drumstick meat			Thigh meat		
	% B.W	Protein (% DM)	Fat (% DM)	% B.W	Protein (% DM)	Fat (% DM)	% B.W	Protein (% DM)	Fat (% DM)
16	10.10	85.64[a]	10.35[a]	6.53	76.4[a]	19.49	8.42	51.17[a]	44.82[a]
10	10.58	87.48[b]	8.42[b]	6.53	75.34	19.65	8.53	55.89[b]	40.10[b]
20	10.56	87.23[b]	8.44[b]	6.68	76.81	19.18	8.52	56.25[c]	39.74[b]

[abc] Figures with different superscripts in the same column differ significantly ($p < 0.05$).

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