II
ブロイラー肉の化学的組成および腹部脂肪の理化学的性状におよぼす影響(ブロイラー飼料における羽毛粉と牛脂の利用)(畜産学科)

Use of Hydrolyzed Poultry Feather and Beef Tallow in the Broiler Ration

II. Effect on physico-chemical properties

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I INTRODUCTION

As the consumer's demand for better meat products has increased, more careful attention must be paied to the fact that quality or characteristics of meat products are chiefly determined by the kinds and levels of ingredients used in the rations (4, 5, 12, 15, 25).

Thus, feedstuffs such as barley, rye, potato, sweet potato, straws, grasses, starch pulp, coconut oil meal and cotton seed oil meal are generally known to produce hard fat. Contrast to these materials, rice bran, oil meals of peanut, rape seed, and meals of silk worm pupa, fish, and soy sauce cake are considered to make the body fat soft (18).

Although many papers concerning with the effect of the hydrolyzed poultry feather and beef tallow usage on the growth of broiler chicks are available, few investigators have studied the influence of protein, energy and sex on the chemical composition of broiler meat and physico-chemical properties of deposited fat as well as the effect on the dissecting yield.

Proximate compositions of thigh and breast muscles, melting point, iodine number, and acid, saponification, and ester values of abdominal depot fat were criteria for evaluating the effect of protein source, energy level and sex on broiler chicks. Also, cholesterol content of breast muscle was determined.

II EXPERIMENTAL PROCEDURE

Breast, thigh meat and abdominal depot fat samples were obtained from 48 birds of White Cornish ♂ x White Rock ♀ used in the previous feeding and dissecting yield trials. Composition, amino acid and energy content of the diets, experimental designs, general management and proceedure for the killing of these birds were reported previousely (13, 24).

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Meat samples of breast and thigh were ground using a meat choper with 5 mm diameter screen and were transfered into polyethylene bottles and stored in freezers at −20℃ until used to assure necessary anaerobic conditon and eventually to prevent chemical alteration due to oxidation and high temperature.

Abdominal adipose tissue was dissolved in an oven at 60℃ and connective tissue was removed before use for determination of the properties studied.

Proximate analysis of breast and thigh muscles was conducted applying the conventional methods except crude protein which was determined employing Morimoto's modified semi-direct distilation apparatus.

Cholesterol content determination of breast muscle lipid was performed according to the Schoenheimer-Sperry method (22) : Dried meat sample was extracted with aceton-alcohol solution (1 : 1) and then the extracted cholesterin ester was saponified with 12.5 N KOH solution. This substance was precipitated with 1% digitonine solution which resulted in the formation of cholestrol digitonide. Following the color development of this substance in acetic solution, the absorption was measured adopting a Hitachi Perkin-Elmer spectrophotometer at wave length of 620 mμ. The standard curve constructed using standard cholesterin and used for the determination of cholesterol level in the breast muscle is presented in Figure 1.

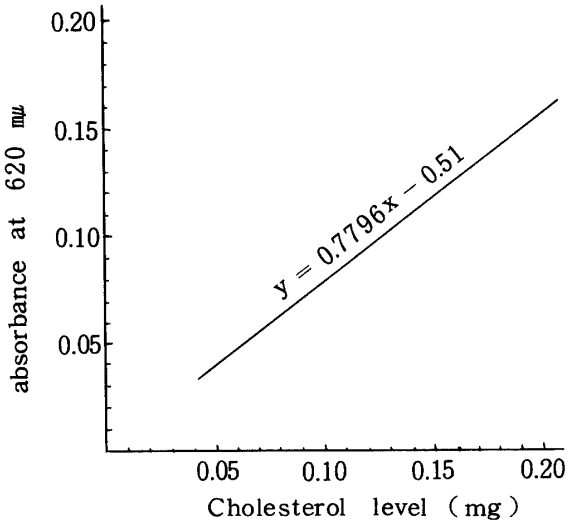

Figure 1. Standard courve for cholesterol content

Acid value, saponification value and iodine number were determined employing methods dscribed in "Experiment in Agricultural Chemistry" by the Department of Agricultural Chemistry, Kyoto University (11).

III RESULT AND DISCUSSION

1. Effect on Proximate Composition

The main effect of protein source, energy level and sex on the proximate composition and interactions of these factors for breast and thigh muscles are shown in Tables 1 and 2.

A. Effect of protein source

No statistical significant differences in amount of moisture, dry matter, crude protein, crude fat and ash were observed between rations with fish and feather meals. This result is similar to that of dissecting yield trial, conducted using the same birds with the present experiment,, where no significant effect of protein source was found on organ weights and other criteria studied except dressing percent when factor of sex was excluded (24). These results seem to be due to the balanced amino acid contents of the formulated rations containing one of these protein sources and probably suggest that nitrogen or amino acids from feather meal be as equally effective for the broilers as those of fish meal when 2 to 5% was used.

B. Effect of Energy Level

Moisture content in thigh muscle of the birds fed the standard energy ration with metabolizable energy (ME) of from 1,220 to 1,300 Cal./lbs. was higher ($P<.05$) than that of chickens fed the high energy ration with ME of from 1,350 to 1,450 Cal./lbs., eventually leading to lower ($P<.05$) dry matter, though no difference was found in breast muscle.

Contrast to the moisture content, the high energy ration showed higher fat value in thigh muscle (2.90%) than the standard energy ration (2.60%) though not statistically significant. Also, decrease in moisture content with increased tissue fat was observed in breast muscle while the differences were not significant in these two criteria. These results are agreeable with those of Marion and Woodroof (12), Donaldson et al. (4), Kliber and Dougherty (1934) and Winchester and Kliber (1938) as reviewed by Mickelberry et al. (15). Although the definite mechanisms involved in the increasing deposition of water content at expense of tissue fat or vice versa are not well known, carcass fat deposition is controled primarily by dietary protein level, or calorie-protein ratio (4). The average calorie-protein ratios in the finishing rations of the present trial were 74.3 and 67.9 for the standard and high energy, respectively.

Energy level significantly ($P<.01$) affected ash content of breast muscle with 1.18% and 1.23% for the standard and high energy rations, respectively while no difference was found in thigh muscle. This result contradict itself to the previous report by the authors that the standard energy ration caused a heavier ($P<.05$) bone weight compared to the high energy ration, 468.25 and 409.16g. The present experiment provides with no answer for this contradiction and leaves

Table 1. Proximate composition of broiler thigh muscle as affected by protein source, energy level and sex[1]

Nutrient	Treatment									
	Protein		Energy		Sex		Interaction[3]			
	FIM[2]	FEM	STE	HIE	Female	Male	EP	ES	PS	EPS
Moisture (%)	76.03[4]	75.61	76.22*	75.44	76.18*	75.47	--	--	--	--
Dry Matter (%)	25.62	24.39	23.78	24.56*	23.82	24.53(*)	--	--	--	--
Ash (%)	1.12	1.10	1.14	1.08	1.12	1.10	--	--	--	--
Crude Fat (%)	2.83	2.68	2.60	2.90	2.63	2.87	--	--	--	*
Crude Protein (%)	21.19	21.26	21.32	21.13	21.09	21.36	*	--	--	--

[1] Comparison was made within each treatment
[2] FIM: fish meal, FEM: feather meal, STE : standard energy, HIE : high energy
[3] EP : energy x protein, ES : energy x sex, PS : protein x sex
[4] Each figure is an average of 24 birds
* Significant at 5% level of probability ($P < .05$)
** Significant at 1% level of probability ($P < .01$)
(*) Close to 5% level of significance ($P > .05$)

Table 2. Proximate composition of broiler breast muscle as affected by protein source, energy level and sex[1]

Nutrient	Treatment[2]									
	Protein		Energy		Sex		Interaction[3]			
	FIM	FEM	STE	HIE	Female	Male	EP	ES	PS	EPS
Moisture (%)	74.45[4]	74.15	74.44	74.16	74.31	74.29	--	--	--	--
Dry Matter (%)	25.55	25.85	25.56	25.84	25.69	25.71	--	--	--	--
Ash (%)	1.15	1.15	1.18	1.23**	1.16	1.14	--	--	*	--
Crude Fat (%)	0.62	0.81	0.65	0.78	0.64	0.79	--	--	--	--
Crude Protein (%)	24.85	25.51	24.95	25.40	25.41	24.94	--	--	--	--

[1] Comparison was made within each treatment

[2] FIM : fish meal, FEM : feather meal, STE : standard energy, HIE : high energy

[3] EP : energy x protein, ES : energy x sex, PS : protein x sex

[4] Each figure is an average of 24 birds

* Significant at 5% level of probability ($P < .05$)

** Significant at 1% level of probability ($P < .01$)

a question of whether there is any difference in patterns of absorption and/or efficiency in usage of minerals absorbed between for the formations of muscle and bone.

The trend in protein content was not similar in thigh and breast muscles. The standard energy ration in thigh muscle had crude protein content of 21.32% which was higher ($P>.05$) than 21.13% of high energy ration while in breast muscle the high energy ration gave higher value (25.40%) than the standard energy ration (24.95%) without showing statistical significance. The tendency of the result in breast muscle was comparable with those of Goodwin et al. (6) and Donaldson et al. (4) who studied the effect of energy level of the diets on the amount of protein of broiler and poult carcasses, respectively. The former workers found the protein content of broiler decreased ($P<.01$) from 67.4 to 65.6 or 65.4% as the energy level increased from 2,149 to 2,314 or 2,488 Cal./kg. of prodctive energy. In case of Donaldson et al. (4), crude protein in poult meat reduced from 19.4 to 16.4% as C/P ratio was widened from 34.7 to 50.8. However, the trend of the result as to thigh muscle was contrast to that in breast muscle but was similar to the one reported by Gardner and Young (5) who observed increase in total protein of egg from 7.03 mg to 7.12 mg due to rise in energy level of the rations used from 2,086 to 2,209 Cal./kg. ($P<.05$).

C. Effect of sex

Female was high ($P<.05$) in moisture content of thigh muscle with 76.18% and 75.47%, respectively; consequently resulting in lower dry matter content with 23.82% compared to 24.53% of male the difference being close to 5% level of probability. The tendency of moisture or dry matter contents in breast muscle of female and male was similar to that of thigh muscle though the difference was not significant. The relationship between moisture and fat contents were the same as mentioned in the section where the effect of energy level on the proximate composition was described; the relationship being inverse or alternative. This relationship in the present work, however, is agreeable neither with that of Goodwine et al. (6) who observed high fat value ($P<.01$) and lower moisture content ($P<.05$) in female nor with that of Miyagi et al. (16). The disagreement in this relationship between the present work and that of Goodwin et al. (6) seems to be partially due to the fact that the latter workers used not only meat but skin and probably even adipose tissue the fat contents of which are high in female than male (10).

No significant differences in ash content existed between sexes both in breast and thigh muscles.

Sex did not affect protein content of both muscles. Summer et al. (25) have shown that male had higher protein value (54.4%) in carcass than female (51.6%) on dry matter basis ($P<.05$). Also, Goodwine et al. (6) noted that on dry matter basis the males contained more protein than females, 67.4 vs 64.4%.

Table 3. Physico-chemical characteristics or properties of abdominal depot fat of broilers as affected by protein, energy level and sex[1]

Item	Treatment[2]									
	Protein		Energy		Sex		Interaction[3]			
	FIM	FEM	STE	HIE	Female	Male	EP	ES	PS	EPS
Melting Point	26.39[4]	25.67	25.97	26.09	25.67	26.39	--	--	--	*
Saponification Value	200.40	200.72	199.65	201.46	200.26	200.85	*	--	--	--
Acid Value	1.90	1.59	1.54	1.95	1.74	1.76	--	--	--	--
Ester Value	198.46	199.04	198.12	199.38	198.46	199.05	*	--	--	--
Iodine Number	72.18	72.43	73.90**	70.70	72.31	72.30	*	--	--	--

[1] Comparison was made within each treatment
[2] FIM: fish meal, FEM: feather meal, STE : standard energy, HIE : high energy
[3] EP : energy x protein, ES : energy x sex, PS : protein x sex
[4] Each figure is an average of 24 birds
* Significant at 5% level of probability ($P < .05$)
** Significant at 1% level of probability ($P < .01$)

These results are confirmed by the observation about thigh muscle of Miyagi et al. (16) with 79.70% and 77.97% on dry matter basis for male and female respectively. However in the present experiment, the content was statistically treated on wet basis.

D. Interaction

Two way interactions in the proximate composition of thigh and breast muscles were not present except energy (E) x protein (P) in protein content of thigh and (P) x sex (S) in ash content of breast muscle.

The summerized interactions are presented in tables 4a and 4b. In former case, the figures were non-additive : At low energy level the protein content of birds fed a ration with fish meal showed higher (21.67%) value than that of those fed feather meal (20.97%) while at high energy level the relation was inverse, 20.97% and 21.55%, respectively. In the latter case, the P x S interaction is due to the fact that male was higher in ash content (6.95%) than female (6.85%) when ration with fish meal was fed but lower (6.67%) than female (7.16%) when ration with feather meal was fed.

Table 4-a. Interaction of protein (P) x energy (E) in protein of thigh muscle (%)

Protein	Energy			Total
	Standard E.		High E.	
Fish M.	21.67[1]	←	20.71	42.38
	↑		↓	
Feather M.	20.97	→	21.55	42.52
Total	42.64		42.26	

[1]Average of 6 birds

Table 4-b. Interaction of protein (P) x sex (S) in ash content of breast muscle (%

Sex	Protein			Total
	Fish M.		Feather M.	
Femal	1.14[1]	→	1.19	2.33
	↓		↑	
Male	1.16	←	1.11	2.27
Total	2.30		2.31	

[1]Average of 6 birds

Three way interaction of E x P x S was with significance ($P<.05$) on fat content of thigh muscle, but no explanation was attempted here because of its complicated relations among the factors.

2. Effect on Physico-chemical Properties of Abdominal Depot Fat

Results about melting point, iodine numer, and values of acid, saponification and ester are given in Table 3.

A. Effect of Protein Source

Factors such as amount, kind and origin of fats or oils to be added to broiler ration for enriching the energy level, environmental temperature at which the birds are raised, level and quality or kinds of other nutrients than fats or oils may affect the physico-chemical nature or characteristics of organ, tissure and deposited fats of chickens (15, 18, 20).

In the present trial, however, protein source did not alter any characteristics determined ; birds on the ration containing fish meal with 26.39, 200.40, 1.90, 198.46 and 72.18 while broilers fed diet of feather meal with 25.67, 200.72, 1.59, 199.40 and 72.43 for melting point, saponification value, acid value, ester value and iodine number of the abdominal depot fat studied, respectively. The authors expected these statistical insignificance due to protein source and planed the trial to investigate the effect of beef tallow and interactions of energy level with protein source as for the fat properties.

B. Effect of Energy Level

The main effect of energy level was not found in any criteria studied except iodine number ($P<.01$) the standard energy (73.90) being higher than the high energy (70.70). Iodine number, as well as melting point and refractive index, is used as a criterion for the degree of fatty acid unsaturation. Saturated fatty acids above C_8 are solid at room temperature while unsaturated fatty acids are liquid and the balance of these two kinds of fatty acids determine the physical characteristics of fats such as hardness, refractive index and melting point (9, 19). Thus, the present trial indicates that the abdominal or muscle lipids of birds fed ration enriched with beef tallow will be low in unsaturated fatty acids.

It is well known that lipids of rice bran, peanut, soy bean, rape seed and fish are generally higher in iodine value, so being liquid form, than those of livestock such as pork, beef etc. Chung et al. (2), Mickelberry et al. (15) and Otake et al. (20) studied the effects of corn oil, lard, dehydrogenated coconut oil and rice bran on the iodine number of breast, thigh, abdominal and liver fats of broilers. These workers have reported that plant oils increased the number while animal fats and dehydrogenation of coconut meal oil decreased the number.

C. Effect of Sex

Factor of sex caused no statistical significant differences in criteria determined.

D. Interaction

Two way interactions of E x P were observed in saponification value, ester value and iodine number. The summerized results are presented in Table 4c, 4d and 4e.

Table 4-c. Interaction of protein (P) x energy (E) in saponification value of abdominal depot fat

Protein	Energy			Total
	Standard E.		High E.	
Fish M.	200.93[1]	←	199.86	400.79
	↑		↓	
Feather M.	198.38	→	203.05	401.43
Total	399.31		402.91	

[1]Average of 6 birds

Table 4-d. Interaction of protein (P) x energy (E) in ester value of abdominal depot fat

Protein	Energy			Total
	Standard E.		High E.	
Fish M.	199.22[1]	←	197.71	396.93
	↑		↓	
Feather M.	197.03	→	201.05	398.08
Total	396.25		398.76	

[1]Average of 6 birds

Table 4-e. Interaction of protein (P) x energy (E) in iodine number of abdominal depot fat

Protein	Energy			Total
	Standard E.		High E.	
Fish M.	72.72[1]	←	71.64	144.36
	↓		↑	
Feather M.	75.09	←	69.77	144.86
Total	147.81		141.41	

[1]Average of 6 birds

Standard energy was higher in saponification value than high energy when fish meal was used as protein source while high energy had a higher value when feather meal was used. Also, as for the ester value, combination of standard energy with fish meal showed higher value than that of high energy.

However, concerning with the iodine number, combination of standard energy with feather meal presented a higher value than fish meal while high energy level showed a higher figure when combined with fish meal than feather meal.

Three way interaction was significant ($P<.01$) in EPS of melting point.

3. Effect on Cholesterol Content

Effects of energy level, protein source and sex on the cholesterin content of breast muscle are given in Table 5, though the data were not statistically treated.

Table 5. Cholesterol content of breast muscle as affected by protein source, energy level and sex

Energy Level							
Standard Energy[1]				High Energy			
Fish[2] Meal		Feather Meal		Fish Meal		Feather Meal	
[3]♀	♂	♀	♂	♀	♂	♀	♂
4.29[4]	3.79	2.56	3.95	3.80	2.77	3.38	3.76

[1]Standard E. vs. high E. (3.65 : 3.76)
[2]Fish meal vs. feather meal (3.66 : 3.16)
[3]Female vs. male (3.26 : 3.57)
[4]Average of 2 samples and on dry basis

The values for standard and high energy were 3.65 and 3.76 mg/g, respectively. Hulett et al. (8) found that replacement of grains with 3.45% animal or vegitable oil depressed serum and liver cholesterol content of 8 week old broilers. However, Daghir and Balloun (3) observed that use of 8% animal fat (white grease) resulted in significantly high serum cholesterol contents both in male and female of Vantress ♂ x Abor Acre ♀ while 8% soybean oil did not elevate serum cholesterol. These workers concluded by considering their own results and reviewing reports of other investigators that feeding of a highly saturated fat to chicks raise serum cholesterol and that a highly unsaturated fat counteracts this effect. McDoniel et al. (14) noted that as C/P ratio was narrowed or as dietary protein level was isocalorically increased a commensurate rise in serum cholesterol was observed.

The cholesterol content of male breast muscle was 3.57 mg／g compared to 3.26 mg／g for female. Daghir and Balloun (3) showed that males had significantly higher serum cholesterol concentrations than did females. Also, Sutton et al. (1958) and Bumgardner and Shaffner (1955), as cited by Daghir and Balloun (1961), reported sex differences for serum cholesterol level.

Ⅳ SUMMARY

Breast, thigh muscle and abdominal depot fat samples of 48 White Cornish x White Rock birds sacrificed at age of 58 days, were used for determination of the effect of protein source, energy level and sex on the proximate compostions of the former two and physico-chemical characteristics of the latter samples. For enrichement of ration energy level, beef tallow was added and as protein sources fish and feather meal were employed.

The results of these investigations were summarized as follows :

1. Protein source caused no significant differences in the amount of any proximate nutrients of both breast and thigh muscles studied.
2. Ration without beef tallow or standard energy level increased ($P<.05$) moisture content of thigh muscle while ration with beef tallow or high energy content elevated dry matter ($P<.05$) of thigh muscle and ash content ($P<.01$) of breast. muscle.
3. Female had higher ($P<.05$) moisture value in thigh muscle than did male.
4. Two way interactions of EP in crude protein content of thigh and PS in ash content of breast muscle were found.
5. Ration with beef tallow or high energy lowered ($P<.01$) the iodine number of abdominal depot fat of the birds.
6. No sex differences were found in the physico-chemical properties studied.
7. Two way interactions of EP were observed in saponification value, ester value and iodine number of abdominal depot fat.

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ブロイラー飼料における羽毛粉と牛脂の利用

Ⅱ ブロイラー肉の化学的組成および腹部脂肪の理化学的性状におよぼす影響

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要　　約

屠殺解体試験の終了した前報と同一の供試鶏について，同様の試験区分に従い，胸筋，大腿筋の一般化学組成，および腹部脂肪の理化学的性状を調査し，蛋白質源(魚粉給与および羽毛粉給与の両試験区)およびエネルギー水準の飼料的，肉質的効果について検討した。

その結果を要約すると大体次の通りである。

1. 飼料中の蛋白質源は，胸筋および大腿筋の一般化学的組成に有意な影響を与えなかった。
2. 牛脂添加による高エネルギー飼料化によって，大腿筋の乾物量と胸筋の灰分量に増加が認められた（$P<.05$）。
3. 大腿筋の水分は，両試験区共，雄よりも雌が高い値を示していた（$P<.05$）。
4. 大腿筋の粗蛋白質はエネルギーと蛋白質源間に，さらに胸筋の粗灰分は，性別と蛋白質源間に，それぞれ交互作用が認められた。
5. 牛脂添加による高エネルギー化は，両試験区共に，腹部脂肪のヨウ素価を著しく減少させた（$P<.01$）。
6. 腹部脂肪の理化学的性状は，両試験区共に，雄雌間に差が認められなかった。
7. 腹部脂肪のケン化価，エステル価およびヨウ素価に対して，蛋白質源とエネルギー間に交互作用が認められた。

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