Effects of Force-feeding and Dietary Cereals on Feed Conversion, Hepatic Lipid Accumulation and Plasma Components in Ducks

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To investigate the effects of force-feeding and dietary cereals on feed conversion, hepatic lipid accumulation and plasma components, Pekin ducks were force-fed on a corn or barley based diet from 43-54 days of age, and the following results were obtained.

Force-feeding markedly increased body weight gain and decreased feed/gain ratio. No significant differences were found in body weight gain and feed/gain ratio between experimental diets.

Force-feeding significantly increased the weights of liver, pancreas, kidney, heart and abdominal fat. Ducks fed on barley based diet had a lighter liver compared to that fed on corn based diet.

Force-feeding caused a relatively higher concentration of liver total lipid and significantly lower concentration of liver non-lipid dry matter. Feeding barley based diet significantly decreased the concentration of liver total lipid and esterified cholesterol, and the ratio of esterified to total cholesterol compared to the corn-based diet. The frequency of occurrence of liver fatty metamorphosis was very high in the ducks force-fed on corn based diet, while no ducks fed on barley based diet were recognized as fatty metamorphosis in liver.

Force-feeding significantly elevated the concentration of all plasma components determined except for esterified cholesterol. Plasma urea was significantly higher in the ducks fed on barley based diet.

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Key words: force-feeding, feed conversion, hepatic lipid accumulation, plasma component, duck

Introduction

It is well known that Pekin ducks have faster growth rate within first few weeks of life compared to other domestic fowls. However, the growth rate obviously slows down and feed/gain ratio markedly rises during the latter stage of growth¹⁻³⁾. Improvement of feed efficiency in the slow rate of growth period is an essential problem in duck production since feed consumption is one of the major items of production cost.

As a means of enhancing the growth rate in the latter stage of growth, force-feeding has been introduced to duck fattening for a long time in China. In general, force-feeding starts on 7 weeks of age and lasts for 10-14 days. Force-feeding has been shown to apparently improve body and organs developments⁴⁾, increase the

activity of pancreas amylase⁵⁾ and enhance the rate of glucose conversion⁶⁾.

However, little is known of force-feeding effect on feed conversion and plasma components. On the other hand, it was noted that force-feeding induces fatty metamorphosis in liver which is undesirable in duck fattening.

The object of the present experiment was to investigate the effects of force-feeding and dietary cereals on growth, feed conversion, hepatic lipid accumulation and plasma components in Pekin ducks.

Materials and Methods

Male Pekin ducklings were obtained from a commercial hatchery at one day old. They were fed on a commercial mash starter containing 20% protein and 2900 kcal/kg ME from 1 to 21 days and a grower diet containing 17% protein and 2770 kcal/kg ME from 22 to 42 days of age. The birds were reared on the floor for 35 days and thereafter they were put in individual wire cages. At 42 days of age, the birds were weighed and divided into 4 groups, 10 birds of each, with similar average body weight. Two experimental diets based on corn or barley were prepared equal in protein, metabolizable energy, methionine and lysine content. The composition of the

Table 1. Composition of experimental diets

	Corn based diet	Barley based diet
Ingredients (g/kg)		
Yellow corn	820	—
Hulless barley	—	800
Soybean meal	123.5	87.7
Fish meal	16.7	16.7
Corn oil	—	56.1
Methionine	2.6	2.8
Lysine	1.7	1.7
Calcium carbonate	16.7	17.3
Tricalcium phosphate	11.3	10.2
Salt	4.0	4.0
Trace mineral mix ¹⁾	1.0	1.0
Vitamin mix ²⁾	2.5	2.5
Calculated analysis		
Crude protein (%)	14.0	14.0
Metabolizable energy (Kcal/kg)	3200	3200
Methionine plus cystine (%)	0.7	0.7
Lysine (%)	0.8	0.8
Calcium (%)	1.19	1.19
Phosphorus (%)	0.58	0.58

- 1) Trace mineral mix provided (per kg diet): 200 mg manganese ($\text{MnSO}_4 \cdot \text{H}_2\text{O}$), 45 mg iron ($\text{FeC}_6\text{H}_5\text{O}_7$), 20 mg copper ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), 10 mg zinc (ZnCO_3) and 0.4 mg iodine (KI).
- 2) Vitamin mix provided (per kg diet): 5000 IU vitamin A, 600 ICU vitamin D₃, 3 mg riboflavin, 50 mg nicotinic acid, 2 mg pyridoxine, 1 mg folic acid, 10 mg calcium pantothenate, 75 mg ascorbic acid, 2.2 mg DL- α -tocopherol, 2 mg thiamine mononitrate, 2 μ g cyanocobalamin, 2 μ g biotin and 200 mg choline chloride.

experimental diets is shown in Table 1.

Experiment was conducted from 43 to 54 days of age. The two experimental diets described above were fed to the four groups of ducks, two groups by *ad libitum*-feeding and two groups by force-feeding. The amount of feed intake in force-feed ducks was 250 g/bird/day initially and increased 50 g every 3 days. Force-feeding was performed 3 times a day at 8 : 30, 16 : 30 and 0 : 30 o'clock. Diet weighed individually was mixed with water (diet : water = 1 : 1.1) and introduced into the crop of the duck with a feeding device as described by SIBBALD⁷⁾. Feed intakes of the two *ad libitum*-feeding groups were recorded daily and body weights of both *ad libitum*- and force-feeding groups were measured every 3 days. At the end of experiment, 5 birds of each group were subjected to blood sampling and then the birds were killed, and abdominal fat, liver, pancreas, heart and kidney were removed and weighed. The livers enlarged and colored from tan to pale yellow were recognized as fatty metamorphosis and recorded. Immediately after blood sampling plasma was separated by centrifuging and after weighing the liver was homogenized with Universal Homogenizer (Tokyo Nihon Seiki Seisakusho Co.) under ice-bath condition. Samples of plasma and liver homogenate were kept at -20°C pending analysis.

The total lipids of liver and plasma were extracted with 2 chloroform : 1 methanol (v : v) as described by FOLCH *et al.*⁸⁾ and determined gravimetrically. Total and free cholesterol in liver and plasma were analysed with purified lipid extracts following the procedure of SCHOENHEIMER and SPERRY as described in Hawk's Physiological Chemistry⁹⁾. Liver dry matter was determined by drying about 5 g sample to constant weight at 105°C. Plasma total and non-protein nitrogens were determined by micro-Kjeldahl method¹⁰⁾. Plasma albumin was determined by the method of DOUMAS *et al.*¹¹⁾ with bovine albumin as standard. Ammonia-Test kit and Uric Acid-Test kit (Wako Pure Chemical Industries, Ltd.) were used for the determination of plasma ammonia and uric acid, respectively. Plasma urea and glucose were determined by urease-indophenol method and GOD-POD method, respectively, with test kits (Wako Pure Chemical Industries, Ltd.).

Data obtained were subjected to analysis of variance. Differences between means were assessed by Duncan's multiple range test¹²⁾.

Results

The body weight gains, feed intakes and feed/gain ratios of the ducks fed by *ad libitum*- and force-feeding on either corn or barley based diet are given in Table 2. Force-fed ducks showed a greater body weight gains and lower feed/gain ratios than that of *ad libitum*-fed ones for all the measured values during 12 days of experimental period. In *ad libitum*-fed ducks, the body weight gains tended to decrease as the birds aged but the feed intakes still kept to increase until 51 days of age ; this resulted in a marked rising of feed/gain ratios. In the force-fed ducks, feed/gain ratios rised only slightly although the feed intake was increased. No significant differences in body weight gains and feed/gain ratios were found between the dietary cereals, though the ducks fed on barley based diet showed a slightly less body weight gains and a slightly

Table 2. Effect of force-feeding and dietary cereals on body weight gain and feed/gain ratio

	<i>Ad libitum</i> -feeding		Force-feeding		Statistical significance		
	Corn	Barley	Corn	Barley	Force-feeding	Dietary cereals	Inter-action
Body weight gain (g/bird) ¹⁾							
Age (days)							
43—45	169±25 ^{2) b}	137±20 ^b	237±20 ^a	230±18 ^a	***	NS	NS
46—48	143±21 ^b	158±22 ^b	246±6 ^a	236±31 ^a	***	NS	NS
49—51	143±23 ^b	145±15 ^b	278±12 ^a	271±16 ^a	***	NS	NS
52—54	95±14 ^b	100±15 ^b	313±17 ^a	303±24 ^a	***	NS	NS
43—54	550±49 ^b	540±41 ^b	1074±52 ^a	1040±46 ^a	***	NS	NS
Feed intake (g/bird)							
Age (days)							
43—45	598	541	750	750			
46—48	601	651	900	900			
49—51	668	682	1050	1050			
52—54	548	606	1200	1200			
43—54	2415	2480	3900	3900			
Feed/gain ratio							
Age (days)							
43—45	3.55	3.95	3.16	3.26			
46—48	4.19	4.11	3.66	3.82			
49—51	4.67	4.70	3.78	3.88			
52—54	5.78	6.06	3.83	3.96			
43—54	4.39	4.59	3.63	3.75			

1) The initial average body weight was 2152 g for the two *ad libitum*-fed groups and 2142 g for the two force-fed groups.

2) Means±SE of 9 birds.

Means with different superscripts within a row are significantly different ($P<0.05$).

*** $P<0.001$; ** $P<0.01$; * $P<0.05$; NS=not significant.

Table 3. Effect of force-feeding and dietary cereals on the weights (g) of liver, pancreas, kidney, heart and abdominal fat

Measure-ment	<i>Ad libitum</i> -feeding		Force-feeding		Statistical significance		
	Corn	Barley	Corn	Barley	Force-feeding	Dietary cereals	Inter-action
Liver	75±11 ^{1) b}	60±7 ^b	129±11 ^a	107±4 ^a	***	*	NS
Pancreas	5.9±0.3 ^b	6.3±0.5 ^{ab}	7.1±0.5 ^{ab}	7.8±0.8 ^a	**	NS	NS
Kidney	17.7±0.8 ^b	17.5±0.4 ^b	22.8±2.2 ^a	23.2±1.7 ^a	**	NS	NS
Heart	18.4±0.6 ^{ab}	17.1±0.4 ^b	22.3±1.3 ^a	22.5±2.3 ^a	**	NS	NS
Abdominal fat	36.8±3.4 ^b	42.2±3.4 ^b	55.2±3.1 ^a	62.6±6.3 ^a	**	NS	NS

1) Means±SE of 5 birds.

Means with different superscripts within a row are significantly different ($P<0.05$).

*** $P<0.001$; ** $P<0.01$; * $P<0.05$; NS=not significant.

Table 4. Effect of force-feeding and dietary cereals on hepatic lipid accumulation

Measure- ment ¹⁾	<i>Ad libitum</i> -feeding		Force-feeding		Statistical significance		
	Corn	Barley	Corn	Barley	Force- feeding	Dietary cereals	Inter- action
Total lipid							
(%)	8.3±3.5 ^{2)ab}	4.5±0.2 ^b	14.7±4.2 ^a	6.3±1.1 ^b	NS	*	NS
(g/liver)	5.5±1.7 ^b	2.7±0.3 ^b	19.3±5.7 ^a	6.7±1.1 ^b	*	*	NS
Total cholesterol							
(mg/g)	4.2±0.5	4.0±0.3	4.9±0.3	3.8±0.1	NS	NS	NS
(mg/liver)	297±25 ^{bc}	232±15 ^c	641±83 ^a	398±8 ^b	***	**	NS
Esterified cholesterol							
(mg/g)	2.1±0.5 ^{ab}	1.8±0.2 ^b	2.6±0.3 ^a	1.6±0.1 ^b	NS	*	NS
(mg/liver)	144±21 ^b	102±7 ^b	342±56 ^a	165±8 ^b	**	**	*
Esterified/total cholesterol	0.49±.07	0.44±.02	0.53±.02	0.41±.02	NS	*	NS
Non-lipid dry matter							
(%)	24.1±0.4 ^a	23.4±0.5 ^a	20.0±1.3 ^b	22.3±0.7 ^{ab}	**	NS	NS
(g/liver)	18.0±2.7 ^{bc}	14.0±1.5 ^c	25.8±2.6 ^a	23.8±0.8 ^{ab}	**	NS	NS
No. of birds of liver fatty metamorphosis ³⁾	1	0	5	0			

1) One and two birds in corn *ad libitum*- and force-feeding groups were respectively recognized as liver fatty metamorphosis among the 5 birds used for chemical analysis.

2) Means±SE of 5 birds.

3) Numbers among 9 birds of each group.

Means with different superscripts within a row are significantly different ($P<0.05$).

*** $P<0.001$; ** $P<0.01$; * $P<0.05$; NS=not significant.

greater feed/gain ratios compared to that fed on corn based diet.

As shown in Table 3, force-feeding significantly increased the weights of liver, pancreas, kidney, heart and abdominal fat, especially the liver weight which increased by 72% in the ducks fed on corn based diet and by 78% in the ducks fed on barley based diet. Feeding barley based diet significantly decreased the liver weight.

Effect of force-feeding and dietary cereals on lipid accumulation and occurrence of fatty metamorphosis in liver is given in Table 4. Force-feeding caused a relatively higher concentration of liver total lipid and significantly lower concentration of liver non-lipid dry matter. As total content (g or mg/liver), all the liver components determined were significantly increased by force-feeding. Ducks fed on barley based diet showed significant decrease in the total lipid and esterified cholesterol as either concentration or total content, total cholesterol as total content, and the esterified to total cholesterol ratio. The frequency of occurrence of liver fatty metamorphosis was very high in the ducks force-fed on corn based diet, while no ducks fed on barley based diet were recognized as fatty metamorphosis in liver.

As shown in Table 5, force-feeding significantly elevated the concentrations of all the plasma components determined except esterified cholesterol. Dietary cereals had no significant influence on plasma components except that the concentration of urea was increased by feeding barley based diet. The esterified to total cholesterol ratios

Table 5. Effect of force-feeding and dietary cereals on plasma components

Measure- ment	<i>Ad libitum</i> -feeding		Force-feeding		Statistical significance		
	Corn	Barley	Corn	Barley	Force-feeding	Dietary cereals	Inter-action
Total nitrogen (mg/dl)	513±3 ^{1) b}	525±18 ^b	587±15 ^a	627±10 ^a	***	NS	NS
Non-protein nitrogen (mg/dl)	19.9±1.3 ^b	20.6±1.1 ^b	30.4±1.0 ^a	28.8±0.9 ^a	***	NS	NS
Albumin (g/dl)	1.71±.05 ^b	1.70±.06 ^b	1.94±.06 ^a	2.05±.03 ^a	***	NS	NS
Ammonia (mg/dl)	0.31±.02 ^b	0.28±.05 ^b	0.51±.08 ^a	0.40±.03 ^{ab}	**	NS	NS
Urea (mg/dl)	0.47±.05 ^c	0.52±.04 ^c	0.83±.13 ^b	1.23±.14 ^a	***	*	NS
Uric acid (mg/dl)	3.85±.18 ^b	3.94±.28 ^b	8.91±.95 ^a	8.11±.55 ^a	***	NS	NS
Total lipid (mg/dl)	576±60 ^b	610±52 ^b	820±53 ^a	913±84 ^a	**	NS	NS
Total cholesterol (mg/dl)	187±11 ^b	184±26 ^b	235±17 ^{ab}	252±15 ^a	**	NS	NS
Esterified cholesterol (mg/dl)	130±7	132±22	154±12	159±17	NS	NS	NS
Esterified/total cholesterol	0.70±.01 ^a	0.72±.02 ^a	0.65±.01 ^b	0.69±.01 ^a	**	*	NS
Glucose (mg/dl)	197±12	194±8	231±15	220±10	*	NS	NS

1) Means±SE of 5 birds.

Means with different superscripts within a row are significantly different ($P<0.05$).

*** $P<0.001$; ** $P<0.01$; * $P<0.05$; NS=not significant.

were significantly higher in the ducks fed on barley based diet and decreased by force-feeding.

Discussion

Previous study has shown that ducks have greater ability to digest a large amount of feed compared to chickens¹³⁾. Even when the feed intake was increased to 200% of *ad libitum* intake, ducks could almost normally digest the over-fed feed¹³⁾. In the present experiment, force-feeding markedly improved the body weight gain and feed conversion. This result indicates that the over-fed feed was efficiently utilized by the ducks. On the other hand, the increase of weights of pancreas, liver, heart and kidney suggests that the metabolic functions such as digestion, nutrients transport and the excretion of metabolic products were enhanced by force-feeding.

On the utilization of barley in poultry, it was shown that barley has a lower nutritional value and digestibility compared to corn for chickens¹⁴⁻¹⁶⁾. But in ducks, Hsu *et al.*¹⁷⁾ reported that no significant differences were found in body weight gain and feed/gain ratio when ducklings were *ad libitum* fed on corn or barley based diet

during 18 to 32 days of age. Furthermore, digestion trial also showed that ducks can digest barley more efficiently than chickens¹⁸⁾. In the present experiment, the differences in body weight gain and feed/gain ratio were very small between corn and barley based diets in either *ad libitum*- or force-feeding. These results indicate that the nutritional value of barley may be higher for ducks compared to chickens and it may be possible to use barley as a main ingredient in ducks diet.

Force-feeding was found to increase the activities of enzymes involved in lipogenesis of liver and elevate the concentration of hepatic total lipids in geese^{19, 20)}. Unlike geese for fatty liver production, the accumulation of lipid in ducks liver is undesirable. It was reported that feeding barley based diet decreased the concentration of hepatic total lipids compared to corn based diet in laying hens²¹⁾. In the present experiment, feeding barley based diet apparently depressed the concentration of hepatic total lipid and prevented the liver from fatty metamorphosis. This result clearly showed that barley has obviously depressive effect on the accumulation of hepatic lipid in ducks.

The concentration of total cholesterol in both liver and plasma of geese were increased by force-feeding²⁰⁾. In the ducks, force-feeding also increased the concentration of total cholesterol in plasma but liver total cholesterol was not affected. Dietary cereals had no effect on the concentration of both hepatic and plasma total cholesterol in the ducks, which agreed with a previous study with ducklings¹⁷⁾. In chickens, however, it was reported that feeding barley based diet apparently decreased both hepatic and plasma total cholesterol²²⁾. It is unknown if the difference between ducks and chickens is specific. Information concerning the influence of nutritional factors on esterified cholesterol is scanty in birds. In the present experiment, force-feeding decreased the esterified to total cholesterol ratio in plasma, while feeding barley based diet induced it to a higher level in plasma and to a lower level in liver. Positive correlation was found between hepatic lipid level and esterified to total cholesterol ratio ($r = 0.683$, $P < 0.01$).

It has been confirmed that liver is the organ to synthesize plasma albumin which is responsible for the transport of nutrients especially lipids²³⁾. Force-feeding had influence on the synthesis of albumin in liver and plasma albumin was negatively correlated to liver weight in force-fed geese²⁴⁾. It was described that albumin synthesis is depressed in the steatic liver and this depression is parallel to the degree of steatosis²⁴⁾. In the present experiment, however, plasma albumin was positively correlated to either liver weight ($r = 0.675$, $P < 0.01$) or liver non-lipid dry matter content ($r = 0.717$, $P < 0.01$), while no correlation was found between plasma albumin and liver lipid content ($r = 0.158$, $P < 0.50$). This result indicates that the ability of albumin synthesis is dependent on the functional fraction of liver, that is the non-lipid dry matter content, and hepatic lipid content has only a little influence on the albumin synthesis in force-fed ducks. However, it should be pointed out that the force-feeding period of the ducks in this experiment (12 days) is shorter than force-fed geese (4-5 weeks) and the degree of lipid accumulation in the liver of ducks is much slighter than geese.

Findings of the present study indicate that 1) force-feeding in the ducks during slow rate of growth period can apparently improve body weight gain and feed conversion ; 2) barley can be used as a major ingredient in the diet for duck fattening without apparently reducing body weight gain and feed efficiency compared to corn ; 3) barley is available to prevent the accumulation of hepatic lipid and the occurrence of liver metamorphosis especially in the case of force-feeding.

References

- 1) HESTER, P.Y., F.W. PIERSON, E.K. WILSON, R.L. ADAMS and W.J. STADELMAN (1981) Feed/gain ratios of White Pekin ducks as affected by age and enviromental temperature, *Poult. Sci.*, **60** : 2401-2406.
- 2) HEZTEL, D.J.S. (1983) The growth and carcass characteristic of crosses between Alabio and Tegal ducks and Muscovy and Pekin drakes, *Br. Poult. Sci.*, **24** : 555-563.
- 3) TESTIK, A. (1988) A study on some characteristics of the Pekin ducks, *Proc. Int. Symp. Waterfowl Prod.*, September 11-18, Beijing, pp. 86-89.
- 4) WANG, Z.S., M.X. LIU and K.Y. LI (1981) The development of the body and the digestive organ of Pekin ducks under different feeding levels, *Chin. J. Anim. Sci.*, No. 5, 11-12.
- 5) LI, K.Y., M.X. LIU and Z.S. WANG (1983) Effect of force feeding on activity of amylase in Pekin ducks, *Chin. J. Anim. Sci.*, No. 4 : 15-16.
- 6) LI, K.Y., M.X. LIU and Z.S. WANG (1984) Influence of force feeding on the glucose tolerance of Pekin ducks, *Chin. J. Anim. Sci.*, No. 1 : 15-17.
- 7) SIBBALD, I.R. (1981) Bioassays based on precision feeding of poultry, *A.R.C. Tech. Bull.*, No. 3 : 7-12.
- 8) FOLCH, J., M. LEES and C.H.S. SLOANE-STANLEY (1957) A simple method for the isolation and purification of total lipids from animal tissues, *J. Biol. Chem.*, **226** : 497-509.
- 9) OSER, B.L. (1965) *Hawk's Physiological Chemistry*, 14th ed., pp.1062-1068. McGraw-Hill Book Co., Inc., New York.
- 10) Association of Official Analytic Chemists (1984) *Official Method of Analysis*, 14th ed., AOAC Inc., Arlington, Virginia.
- 11) DOUMAS, B.T., A. WATSON and H.G. GIGGS (1971) Albumin standards and the measurement of serum albumin with bromocresol green, *Clin. Chim. Acta*, **31** : 87-96.
- 12) DUNCAN, D.B. (1955) Multiple range and multiple F test, *Biometrics*, **11** : 1-42.
- 13) ZHOU, Z.-X., Y. ISSHIKI, K. YAMAUCHI and Y. NAKAHIRO (1989) Effects of feeding method and feed intake on the feed digestibility and activities of digestive enzymes in the feces of ducks, *Jpn. Poult. Sci.*, **26** : 354-361.
- 14) ARSCOTT, G.H., J. E. JOHNSON and J.E. PARKER (1955) The use of barley in high-efficiency broiler rations. 1. The influency of methionine, grit and stabilized animal fat on efficiency of utilization, *Poult. Sci.*, **33** : 655-662.
- 15) ISSHIKI, Y., H. SHIN and Y. NAKAHIRO (1980) Study on the digestibility and feed passage in alimentary tract of barley in the chicken, *Tech. Bull. Fac. Agr. Kagawa Univ.*, **32** : 17-20.
- 16) ISSHIKI, Y., H. SHIN, K. OHMATSU and H. UEDA, (1980) The use of barley in broiler rations, *Tech. Bull. Fac. Agr. Kagawa Univ.*, **32** : 13-16.
- 17) HSU, J.-C., K. TANAKA and S. OHTANI (1987) Effect of diets with different protein levels and cereals on hepatic lipid accumulation and on the activities of lipogenic-related enzymes in the liver of ducklings, *Jpn. Poult. Sci.*, **24** : 94-102.
- 18) ZHOU, Z.-X., Y. ISSHIKI, K. YAMAUCHI and Y. NAKAHIRO (1989) A comparative investigation on feed digestibility and feed passage rate in waterfowls and chickens,

- Tech. Bull. Fac. Agr. Kagawa Univ., **42**: 111-117.
- 19) SHAPIRA, N., I. NIR and P. BUDOWSKI (1978) Response of lipogenic enzymes to overfeeding in liver and adipose tissue of light and heavy breeds of chicks, *Br. J. Nutr.*, **39**: 151-157.
 - 20) NIR, I. and M. PEREK (1971) The influence of various protein levels in feed of goslings during the preparatory period on fatty liver production and blood plasma components, *Annal. Biol. Anim. Biochim. Biophys.*, **11**: 645-656.
 - 21) JENSEN, L.S., C.H. CHANG and R.D. WYATT (1976) Influence of carbohydrate source on liver fat accumulation in hens, *Poult. Sci.*, **55**: 700-709.
 - 22) QURESHI, A.A., W.C. BURGER, N. PRENTICE, H.R. BIRD and M.L. SUNDE (1980) Regulation of lipid metabolism in chicken liver by dietary cereals, *J. Nutr.*, **110**: 388-393.
 - 23) BULTER, E.J. (1971) *Physiology and Biochemistry of the Domestic Fowl* (BELL, D.J. and B.M. FREEMAN, eds.): pp. 933-961. Academic Press Inc., London.
 - 24) NIR, I. (1972) Modifications of blood plasma components as related to the degree of hepatic steatosis in the force-fed goose, *Poult. Sci.*, **51**: 2044-2049.

アヒルに対する強制給餌が飼料要求率, 肝臓脂質 および血漿成分に及ぼす影響

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ベキンアヒルを用いて成長速度の遅くなる7週齢から12日間に渡りトウモロコシ又は大麦を主体とした飼料を強制給餌し, 増体量, 飼料要求率, 臓器の重さ, 肝臓脂質および血漿成分について検討した。

増体量, 飼料要求率は, 両飼料区ともに強制給餌によって大幅に改善されたが, 飼料間では大麦飼料給与区の方が僅かに劣った。

肝臓, 脾臓, 腎臓, 心臓および腹腔脂肪はいずれも強制給餌区の方が重くなった。飼料間では大麦飼料給与区は肝臓が軽かった。

単位あたり肝臓成分含量は強制給餌によって総脂質が増加の傾向を示したが, 非脂質乾物質が有意に低下した。一方, 大麦飼料給与区は総脂質, エステル型コレステロールが低かった。脂肪肝の発生率は, トウモロコシ飼料

の自由摂取区と強制給餌区で9羽中に1羽と5羽それぞれみられたが, 大麦飼料給与区では認められなかった。

血中窒素成分, 脂質成分およびグルコース濃度は強制給餌によって高くなった。飼料間では大麦飼料給与区は尿素が高い値を示した。

以上の結果から, アヒルの飼料利用性は強制給餌によって改善されるが, 大麦飼料の利用性は比較的高く, しかも脂肪肝の発生がみられなかった事から推察するとアヒルの強制肥育用飼料として大麦は期待ができるであろう。

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キーワード: 強制給餌, 飼料要求率, 肝臓脂質, 血中成分, アヒル