Original Research

Effects of Feeding Frequency on Fat Deposition and Growth Performance in Broiler Chickens

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Abstract

This experiment was conducted to study the effect of feeding frequencies on the fat deposition and growth performance in broilers. Two hundred and forty, day old broiler chicks were randomly assigned into five treatments in a completely randomized design. Treatments were as follows; feeding four times, three times, two times: at 0630 and 1230 h, two times: at 0630 and 1830 h and one time per day. Chicks were fed with commercial broiler rations. The highest feed intake was reported for birds fed four time per day. Serum high density lipoprotein (HDL) levels were significantly higher (P < 0.05) in birds fed four times per day compared to control treatment. Abdominal fat contents of carcass were significantly lower and muscle protein contents were significantly higher (P < 0.05) in birds fed three and four times per day compared to control treatment. Three times per day feeding is a better solution to improve the meat quality, while reducing abdominal fat pad without interfering on growth performances of broilers with lower cost.

Key words: Abdominal Fat, Broilers, Carcass Quality, Feeding Frequencies, Lipid Profile

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Introduction

Meat industry plays a significant role in livestock sub sector of Sri Lanka and the highest contribution is coming from chicken meat which accounts about 70% to the sub sector. Chicken meat is relatively cheap compared to other animal products thus made it most consumed animal protein sources in the average Sri Lankan diets (Alahakoon *et al.*, 2016). The sustainability and profitability of broiler industry can be effectively achieved with improved growth rates, feed efficiency and healthy birds (Baracho *et al.*, 2006). More than 70% of total expenses in broiler management account in the form of feed management (Neves *et al.*, 2014). Therefore, efficiency in feeding is one of the key factors for successful poultry production.

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The demand of poultry meat mainly depends on consumer's perceptions and meat quality. Today, consumers are keener and demand is increased with high lean content, low in fat, cholesterol and calorie meat. However, broiler chickens have been improved for increased body weight gain, feed efficiency, growth rate, and breast muscle weight (Wang *et al.*, 2012) and these modern broiler strains contain excessive fat in their carcass (Zhou *et al.*, 2006). As Choct *et al.* (2017) stated, modern broiler strains contain 15% - 20% fat in which more than 85% is considered as not physiologically required for body function. During processing the carcass, part of the deposited fat is removed which results lessening the yields. Further, remained fat in the ready to cook bird gives the fatty image to the chicken meat (Leenstra, 2007). Therefore, excessive fat deposition is an unfavorable trait for both producers and consumers because, it is considered to be wasted dietary energy and a waste product with low economic value, which also reduces the carcass yield and quality that affect consumer acceptance (Emmerson, 1997). Thus, there is a great attention in broiler industry to reduce the fat content of its products due to producers perspective and greater consumer awareness of a dietary fat and its adverse effects on human health. Dietary composition and feeding strategies may offer practical and efficient solutions for reducing body fat deposition in modern poultry strains by regulating lipid metabolism which reduces the abdominal fat content while facilitating production (Yu and Robinson, 1992).

Nutritional factors and proper feeding patterns can regulate body fat deposition (Buyse and Decuypere, 2003). Therefore, feeding pattern is one of the most significant factors in broiler industry for producing good quality meat by fulfilling consumer demand. Thus, this study was conducted to evaluate the effect of feeding frequency on fat deposition, growth performance and meat qualities of broiler chicken.

Materials and Methods

Experiment Location

Field works and laboratory analysis were conducted at Livestock Farm and Animal and Food Science laboratory, respectively in Faculty of Agriculture, Rajarata University of Sri Lanka.

Birds and Experimental Design

Two hundred and forty Cobb 500, day old broiler chicks were purchased from a commercial hatchery in Sri Lanka and randomly assigned into five treatments designated as T1, T2, T3, T4 and T5 in a Complete Randomized Design (CRD). Each treatment was replicated four times and there were 12 birds in each replicate. Treatments were as follows-

T1 – 25% equal meals feeding of total feed allocation at 0630, 1030, 1430 and 1830 h (four times)
T2 – 33% equal meals feeding of total feed allocation at 0630, 1230 and 1830 h (thrice)
T3 – 50% equal meals feeding of total feed allocation at 0630 and 1230 h (twice, 6 h gap)

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T4 – 50% equal meals feeding of total feed allocation at 0630 and 1830 h (twice, 12 h gap)
T5 – 100% total meal feeding at 0630 h (once, control)

Total feed allocation was similar among the treatments. Daily feed allowance was adjusted according to the recommendation made by Veterinary Research Institute (VRI), Sri Lanka (Table 1).

Table 1: Feeding recommendations for broiler chickens

Age (wks.)	Amount required (g)/bird	Ration
1	15	Starter
2	40	Starter
3	55	Starter
4	80	Finisher
5	110	Finisher
6	140	Finisher

(Source: VRI recommendations, DAPH, 2015)

Broiler Management Practices

Before the chicks' arrival, rooms, brooder guards, feeders and waterers were thoroughly cleaned. Day old broiler chicks were weighed and they were randomly introduced into brooders and reared under good hygienic conditions. Chicks were spent seven days of brooding period and 100 W electric bulbs were used to provide the initial heating and lighting. Paddy husk was used as the litter material. All chicks were provided with Vitamin E (Selvite-E) and glucose solution with drinking water to reduce the stress. All birds were vaccinated against infectious bursal disease (IBD) at age of 7 and 14 days.

Commercial broiler starter (fed from d 1 to d 21) and finisher (fed from d 22 until slaughter) feeds were used and proximate composition of the feed as given by the feed manufacturer is presented in Table 2. Water was provided *adlibitum.* All other general management practices were followed until the birds were slaughtered.

Table 2: Nutritional composition of commercial feeds

Nutrients	Starter	Finisher
Protein (%)	22	20
Fat (%)	6	7
Ash (%)	7	7.5
Fiber (%)	4.5	4.5
Calcium (%)	9.5 - 1.2	0.9 - 1.2
Phosphorous (%)	0.7 - 1	0.7 - 1
Metabolizable Energy (kcal / kg)	3000	3100

(Source: CIC Agri-Business, 2017)

Slaughtering of Birds

Three birds were randomly selected from each replicate at 40th days of age and they were slaughtered. Anti-mortem inspections were done by visual observations. The birds were fasted for 12 hours. They were kept

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in killing cones and major blood vessels (carotid arteries and jugular veins) were cut within 10 seconds and kept for bleeding at least for 2 minutes. Slaughtered birds were scaled in hot water (56 ^{0}C) for 2 - 5 minutes. Feathers were removed by de-feathering machine and remained feathers were shaved by a shape knife. Then a cut was made at the end of the abdomen and abdominal cavity was opened and digestive tract, respiratory tract and heart were removed. Liver was removed and gall bladder was peeled away. Gizzard was cleaned and inner layer was removed.

Data Collection and Calculations

Growth Performance

Feed intake was calculated daily throughout the study period by measuring given feed and remained feed per pen. Body weight was measured weekly and weight gain and feed conversion ratio (FCR) were calculated. Live weight and carcass weights were recorded and dressing percentage was calculated. The weights of internal organs (liver, gizzard, small intestine, caeca, pancreas and heart) were taken and expressed as percentage of the live slaughter weight. The weights of heart, liver, gizzard and neck as giblets were recorded. Weights of abdominal fat and carcass parts were also measured.

Serum Lipid Profile

Blood samples were collected to sterilized tubes (without anticoagulant) during the bleeding from four randomly selected fasting birds representing each replicate. Immediately, serum was separated by centrifugation at 1500 rpm for 20 min (Labnet Int. - C0060-240V, USA). Then, samples were stored in -20^{0}C until further analysis. Three serum samples from each replicate were tested for total cholesterol, high density lipoproteins (HDL), triglycerides (TAG) and low density lipoproteins (LDL) as per the manufacturers guidelines (BIOLABO, France) using a spectrophotometer (LABOMED, USA).

Meat Quality Parameters

After slaughtering the birds, meat samples were taken from breast area. Dry matter, crude fat, crude protein, total ash, crude fiber contents in meat were analyzed according to the association of Official Analytical Chemist Methods (AOAC, 2005). Fat was extracted from the breast muscle samples following the method described by AOAC (2005) and methylated and fatty acid composition were analyzed with a gas chromatograph (GC-14A, Shimadzu, Japan) equipped with a flame ionization detector according to the ISO12966 (2015) at Industrial Technology Institute, Colombo, Sri Lanka.

Cost Benefit Analysis

The feed cost for different treatments were noted throughout the study period. Feed intake per bird during the study period was used to obtain the cost of feed consumed by a bird. Cost for other management practices were also accounted. Carcass weight and selling price were used to calculate the earnings.

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Data Analysis

Growth performances, lipid profile and meat composition data were analyzed using the Analysis of Variance (ANOVA) procedure of Statistical Software for Data Analysis, Ver 9.0 (SAS, 2002). Mean separation was done by Turkey's Standardized Range Test (TSRT). Statistical significance was declared at $P < 0.05$.

Results and Discussion

Growth Performances

Table 3 shows the effect of feeding frequency on growth performances of broiler chicken. During the study period, weight gain of birds was not significantly different ($P > 0.05$) among treatments (Table 3).

Table 3: Effect of feeding frequency on growth performances of broiler chicken

Parameter	Treatments					SE
	Four times	Thrice	Twice 6	Twice 12	Once	
Initial body weight (g)	40	40	40	40	40	0.02
Weight gain (g/bird)	1817	1848	1776	1858	1808	54
Starter period	1027	1074	1109	106	1162	31
Finisher period	790	774	667	790	646	53
Daily weight gain (g)	45	46	44	46	45	2
Feed intake (g/bird)	2321^{a}	2257^{ab}	2019^{b}	2281^{ab}	2117^{ab}	64
Starter period	825^{a}	792^{b}	775^{b}	790^{b}	772^{b}	13
Finisher period	1496^{a}	1465^{ab}	1244^{b}	1492^{ab}	1345^{ab}	57
FCR	1.28	1.22	1.14	1.23	1.17	0.03
Starter period	0.80^{a}	0.74^{abc}	0.70^{abc}	0.74^{abc}	0.66^{bc}	0.02
Finisher period	1.92	1.91	1.87	1.9	2.09	0.1

Data are presented as means ± SE; $^{a, b, c}$ means within the same row with different superscripts are significantly different ($P < 0.05$).

The lack of significant effect to live body weight gain in the present study may be due to physiological adaptation of the birds to the different feeding regimes and probably improving the efficiency of conversion of the feed available to them. However, Farghly and Hassanien (2017) stated that body weight gain of birds was significantly affected by different feeding frequencies.

There was a significant difference ($P < 0.05$) among feed intake in broiler chickens fed with different treatments (Table 3). During the starter period, feed intake of birds fed four times per day was significantly higher ($P < 0.05$) compared to the other treatments. The available energy is utilized for maintenance, growth and development. Feed availability and feeding frequency play an important role during growth phase (Saber *et al.*, 2011). It has been shown that increased feeding frequency improves the feed utilization through improvements in nutrient digestibility (Fanimo *et al.*, 2003). This could be a reason for the higher feed intake reported in four times per day feeding during starter, finisher and whole study periods. The

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results of present study agreed with the findings of Ozkan *et al.* (2003) who reported that there was a significant effect on feed intake and feed efficiency with the increased feeding frequency. Bley and Bessei (2008) also have shown that feed intake is increased with the age and significant changes in feeding frequency. During the total study and finisher periods, FCR of birds fed with different feeding frequencies was not significantly different ($P > 0.05$). However, FCR was significant ($P < 0.05$) among treatments during starter period (Table 3). The results obtained in the study for FCR agreed with Saber *et al.* (2011) and Jones and Farrell (1992) who reported that FCR was not affected with changing of feeding frequencies.

Meat Quality Parameters

The effect of feeding frequency on carcass yield and meat quality of broiler chickens is shown in Table 4. Carcass yield parameters such as live weight, carcass weight, dressing percentage, abdominal fat, breast, leg and thigh and wing weights were considered.

Table 4: Effect of feeding frequency on carcass yield and meat quality (breast) of broiler chickens

Parameter	Treatments					SE
	Four Times	Thrice	Twice 6	Twice 12	Once	
Carcass Yield						
Live weight, g	1857	1888	1816	1898	1848	54
Carcass weight, g	1668	1669	1524	1617	1551	53
Dressing percentage, %	89.9	88.5	84.1	85.3	84.3	3.3
Abdominal fat, g	12^{a}	14^{a}	23^{b}	24^{b}	26^{b}	3
Breast, g	500	600	578	492	465	30
Leg and thigh, g	458	455	422	426	445	14
Wings, g	162	162	168	161	162	6
Meat Quality (Breast)						
Ash, %	1.4^{a}	3.1^{c}	2.4^{b}	1.7^{a}	2.5^{b}	0.17
Crude protein, %	9.7^{a}	11.8^{b}	7.9^{c}	8.6^{e}	6.1^{d}	0.2
Crude fat, %	2.9	2.9	3.2	2.8	3.2	0.01
Fiber, %	2.6^{a}	1.7^{b}	1.5^{c}	1.8^{b}	1.9^{d}	0.03
DM, %	33.1	30.4	34.7	33	42.7	0.6

$^{a, b, c, d}$ *means within the same row with different superscripts are significantly different ($P < 0.05$)*

Carcass yield parameters except abdominal fat did not significantly differ ($P > 0.05$) among different feeding frequencies (Table 4). There was a significant difference ($P < 0.05$) in abdominal fat content of birds. Significantly lower abdominal fat content was observed in the birds fed with four and three time per day compared to others. Results of this study were agreed with Taherkhani *et al.* (2010) who found that abdominal fat content was decreased while increasing frequency of feeding up to three times per day with feed restriction in broiler breeder hens. However, weights of breast, legs, thighs and wings were not significantly different ($P > 0.05$) among the birds fed with different feeding frequencies.

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Ash, crude protein, crude fat, crude fiber and dry matter were analyzed as meat quality parameters. Total ash and crude protein content in meat samples of birds showed a significant difference ($P < 0.05$) among treatments. Total ash percentage ranged from 1.4 to 3.1 in the present study. The highest total ash content was reported in birds fed three times per day (Table 4). The results of this study were similar with the findings in Pesti and Bakalli (1997) who concluded that ash content ranged between 0.58% - 3.81% in broiler meat. Three times per day feeding reported the highest protein values whereas the lowest was reported in the control treatment. The crude fat level of breast meat taken from birds showed no significant difference ($P > 0.05$) among treatments. There was a significant difference ($P < 0.05$) in crude fiber content of meat samples taken from birds and the highest crude fiber content was reported in four times per day feeding. The dry matter content of breast meat taken from birds showed no significant difference ($P > 0.05$) among treatments.

Fatty Acid Profile

The Table 5 shows the effect of feeding frequency on breast meat fatty acid profile of broiler chickens. Total SFA content did not differ in breast meat however; lowest SFA was reported in three times per day feeding. The higher values for both MUFA to SFA and PUFA to SFA in breast meat were observed in thrice feeding per day as 1.66 and 0.65, respectively. The lowest n-6 to n-3 (10.01) was reported in twice feeding per day (twice feeding 12 h interval). The composition of poultry meat can be modified by feeding management (Bostami *et al.*, 2017) and dietary fatty acid composition affects the body fat deposition in broilers (Scaife *et al.*, 1994). In addition, poultry meat is considered as low fat meat which is deliberated as the principal source of polyunsaturated fatty acids (PUFA) with higher concentration of n-3 PUFA. The higher levels of polyunsaturated fatty acids (PUFA) in the meat enhance the consumer demand due to its health aspects. Linoleic and linolenic acid are essential PUFA for humans and hence chicken meat is a good source for these essential fatty acids in human diet (Boselli *et al.*, 2008; Mitchaothai *et al.*, 2007). As per the finding of Mandal *et al.* (2014) who concluded that decreased ratio of n-6/n-3 FA in poultry meat gives the healthy chicken products which is beneficial for consumers.

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Table 5: Effect of feeding frequency on breast meat fatty acid profiles of broiler chickens

Fatty acid (g/100 g of fat)		Four times	Thrice	Twice 6	Twice 12	Once
Lauric acid	C12:0	0.24	0.25	0.26	0.25	0.25
Myristic acid	C14:0	0.89	0.89	1.11	0.93	0.92
Palmitic acid	C16:0	24.6	23.34	30.68	25.05	24.84
Stearic acid	C18:0	6.01	5.07	5.48	5.85	5.83
Arachidic acid	C20:0	0.06	0.08	0.14	0.09	0.08
Total SFA		**31.8**	**29.63**	**37.67**	**32.22**	**31.92**
Palmitoleic acid	C16:1 n-7	5.29	6.06	5.48	5.58	5.58
Palmitoleate acid	C16:1 n-9	ND	ND	ND	ND	ND
Vaccenic acid	C18:1 n-7	ND	ND	ND	ND	ND
Oleic acid	C18:1 n-9	41.92	42.51	42.05	43.24	43.06
Paullinic acid	C20:1 n-7	0.03	0.22	0.03	0.03	0.04
Eicosenoic acid	C20:1 n-9	0.48	0.44	0.46	0.42	0.32
Total MUFA		**47.72**	**49.23**	**48.02**	**49.27**	**49**
Linoleic acid	C18:2 n-6	15.87	16.23	17.65	14.91	14.65
Eicosadienoic acid	C20:2 n-6	0.16	0.15	0.12	0.12	0.11
DG linolenic acid	C20:3 n-6	0.14	0.2	0.12	0.12	0.11
Arachidonic acid	C20:4 n-6	0.28	0.21	0.24	0.24	0.22
Adrenic acid	C22:4 n-6	0.41	0.41	0.99	0.41	0.71
Docosapentaenoic acid	C22:5 n-6	0.15	0.12	0.16	0.12	0.15
Total n-6		**17.01**	**17.32**	**19.28**	**15.92**	**15.95**
Linolenic acid	C18:3 n-3	0.05	0.55	0.06	0.05	0.04
Octadecatetraenoic acid	C18:4 n-3	0.69	0.73	0.71	0.67	0.66
Eicosatrienoic acid	C20:3 n-3	ND	ND	ND	ND	ND
Eicosatetraenoic acid	C20:4 n-3	0.07	0.03	0.08	0.08	0.09
Eicosapentaenoic acid	C20:5 n-3	0.12	0.13	0.18	0.18	0.2
HPA	C21:5 n-3	0.57	0.58	0.07	0.58	0.03
Docosapentaenoic acid	C22:5 n-3	0.04	0.03	0.04	0.03	0.04
Total n-3		**1.54**	**2.05**	**1.14**	**1.59**	**1.06**
Total PUFA		**18.55**	**19.37**	**20.42**	**17.51**	**16.71**
MUFA/SFA		**1.5**	**1.66**	**1.27**	**1.53**	**1.54**
PUFA/SFA		**0.58**	**0.65**	**0.54**	**0.54**	**0.52**
n-6/n-3		**11.05**	**26.65**	**16.91**	**10.01**	**15.04**

ND : Not detected (Limit of detection = 0.001 g/ 100 g), HPA : Heneicosapentaenoic acid; SFA : saturated fatty acid; MUFA : mono-unsaturated fatty acid; PUFA: poly-unsaturated fatty acid

Blood Serum Parameters

The Table 6 shows the effect of feeding frequency on serum lipid profile of broiler chicken. The total cholesterol levels in birds showed a significant difference ($P < 0.05$) with different feeding frequencies (Table 6). The highest total cholesterol level was reported in birds fed once a day while the lower level of serum cholesterol was reported in birds fed three and four times per day. Moradi *et al.* (2013) concluded that the plasma level of cholesterol was lower in multi-meal-fed birds compared with birds fed once a day at 38 of age. The results of this study were agreed with above conclusion. The HDL values were also significantly different ($P < 0.05$) among treatments.

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Table 6: Effect of feeding frequency on serum lipid profile of broiler chickens

Parameter	Treatments					SE
	Four times	Thrice	Twice 6	Twice 12	Once	
Cholesterol, mg/dL	168[a]	175[ab]	188[c]	179[b]	198[d]	0.93
LDL, mg/dL	87	95	112	101	122	6.01
HDL, mg/dL	39[a]	37[b]	35[c]	32[d]	31[d]	0.92
Triglycerides, mg/dL	78	85	95	91	102	7.02

[a, b, c, d] means within the same row with different superscripts are significantly different (p < 0.05); LDL : Low density lipoproteins, HDL: High density lipoprotein

Higher HDL values were observed in birds fed four and three times per day while the lowest was reported in birds fed once a day. These were agreed with the findings of Abougabal (2015) who concluded that changing feeding frequencies of broiler chicks led to reduced serum cholesterol, triglyceride and LDL and increased HDL which may be beneficial to produce healthy products for consumers.

Low density lipoprotein levels and triglycerides in blood serum were not significantly different (P > 0.05) in birds fed with different feeding frequencies. Numerically, lower LDL and triglycerides values were reported in birds fed with four and three times per day, respectively. Taherkhani *et al.* (2010) found that increasing feeding frequency resulted in lower plasma triglyceride levels compared with feeding once a day

Cost-Benefit Analysis

Table 7 shows the cost-benefit analysis of the experiment. The initial feed cost for all treatments were similar due to supplying same amount of feeds per birds in all treatments. Also cost for medications and other management practices were similar among all treatments. Therefore, total cost was approximately equal in all treatments.

Table 7: Effect of feeding frequency on total cost, total revenue and profit

Parameter	Treatments				
	Four times	Thrice	Twice 6	Twice 12	Once
Total cost / bird, SLR	410.5	401	406	406	406
Total revenue / bird, SLR	650.67	650.74	594.3	605.01	630.65
Profit, SLR	**240.17**	**249.74**	**188.3**	**199.01**	**224.65**

SLR = Sri Lanka rupees (1$ = Rs. 154.00)

The highest total revenue and profit were reported in birds fed four and three times per day when birds slaughtered at 40 days age. These results were agreed with Hassanien (2011) who concluded that changing the frequency of feeding improves economic efficiency.

Conclusion

Three times per day feeding is the best solution for rearing broiler birds to improve the meat quality while reducing abdominal fat pad with low cost of production.

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