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Effect of Stocking Density and Feeding Regime on Performance of Broiler Chicken in Summer Season

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Abstract: A total of five-hundred and fifty (550) day-old Cobb-500 broiler chicks were used for a period of six weeks to study the effect of different stocking densities and feeding regime on the performance of broiler chicken. The treatments under stocking densities were D_1 (8 bird/m^2), D_2 (10 bird/m^2), D_3 (12 bird/m^2) and D_4 (14 bird/m^2). The form of feeds under feeding regime was F_1 (mash), F_2 (crumble) and F_3 (pellet) feeds. The study revealed that the lower stocking density D_1 consumed significantly ($p<0.05$) the highest amount of feed and in terms of feed form F_2 group consumed significantly ($p<0.05$) the highest amount of crumble feed and among the interaction between 'density x feed' D_2F_2 consumed significantly ($p<0.05$) the highest amount of feed. The average live weight of birds under stocking density D_3 was significantly ($p<0.05$) higher compared to other density groups; there was no significant difference ($p<0.05$) among the mash, crumble and pellet groups. The interaction between D_3F_2 was achieved significantly ($p<0.05$) highest live weight than other treatment groups. Irrespective of feed type, FCR value was significantly better in D_4 and D_3 ($p<0.05$) compared to D_2 and D_1. Similarly irrespective stocking density, crumble feed performed better FCR compared to others and the interaction group D_3F_2 showed significantly better ($p<0.05$) FCR compared to other combinations. The birds under lower stocking density D_1 consumed significantly ($p<0.05$) the highest amount of water; but the form of feeds (F_1, F_2 and F_3) had no significant ($p<0.05$) effect on water intake and the water intake was significantly higher ($p<0.05$) in D_1F_1 compared to other treatments. No significant difference ($p<0.05$) in mortality was found among different stocking densities, feeding regime and different interaction groups. The Benefit Cost Ratio (BCR)/m^2 under D_3 was significantly ($p<0.05$) higher compared to others; the F_1, F_2 and F_3 feeds had no significant effect on BCR and D_3F_2 group was significantly ($p<0.05$) profitable than other combinations. The dressing % of stocking density D_1 and D_2 were significantly ($p<0.05$) higher compared to D_3 and D_4. No significant difference ($p<0.05$) in dressing % was found among F_1, F_2 and F_3 feeds, similar results were observed in different carcass parts for stocking density and feed types. Significantly higher ($p<0.05$) abdominal fat deposition were found higher in D_3 and D_4. Lower stocking density showed higher dressing percent. The stocking density and feeding regimes had no significant effect on different carcass parts of broiler except higher abdominal fat deposition was found in higher stocking density groups. Finally, it can be concluded that during summer the stocking density 12 bird/m^2 fed on crumble feed may be profitable for commercial broiler production up to six weeks in Bangladesh condition.

Key words: Broiler, density, feed type, performance, summer, profit

INTRODUCTION

Broiler farming has been recognized as a profitable enterprise and seemed to be a much-preferred agro business than ruminants. It can be harvest for human consumption within a very short period of time. Broiler farming is a rapid income generating source for the rural women and un-employed youths. Per capita annual meat consumption of Bangladesh is 4.57 kg (standard 43.8 kg/year) which indicates a huge demand for increasing the production of broiler meat and its related industry (Rahman, 2003). Bangladesh is a tropical country with climatic variations which influence broiler production. Poultry husbandry in tropical and sub tropical countries are affected by stocking density and increased temperature (Beg, 1993). Research performed in open sided house shows that seasonal variation has significant effect on total body weight gain of broilers (Saleque and Rozen, 2007) where impact of stocking density and feeding system were ignored. There is few published literature concerning the influence of stocking density with feeding regimes in summer season. High environmental temperature impairs the growth and feed intake of broilers (Charles, 1986). Change in season and the season of rearing period, influences the growth performance of chicks. Yalcini et al. (1997) found that body weight and body weight gain of broilers reared

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during summer was lower as compared to those reared during winter. Deaton *et al.* (1989); Wabeck *et al.* (1994), Al-Ribdawi and Singh (1989) also reported lower body weight for broilers reared during summer. In addition, Imaeda (2000) reported lower body weight of broilers during summer irrespective of stocking density. Many countries have initiated programs aimed at improving small-scale poultry as a means of helping to bring socio- economic benefits to rural communities.

Stocking density is reported using the number of birds per unit area or the amount of area per bird through out their life which reduces their opportunity for movement during the later stage of rearing. Stocking density 10 bird/m^2 is practiced in tropical countries (Hulzebosch, 2004). Farmers rear broilers ignoring stocking density in different seasons due to high price of construction materials and lack of knowledge. High stocking density creates health hazard in poultry shed. It might be hypothesized that farmers need to consider housing density with feed types to maximize profitability. Studies on stocking densities in broiler production have produced variable conclusions. Some studies show large benefits in reducing stocking density, while others show little or no differences. Biligili and Hess (1995) concluded that body weight, feed conversion, mortality, carcass scratches and breast meat yield were significantly improved when birds were given more space. Beg *et al.* (1994) found lower growth rate at higher density in open-sided house. In contrast, Feddes *et al.* (2002) demonstrated that when bird density was reduced, live body and carcass weights were also decreased.

In poultry industry mash, crumble and pellet feeds are generally used. Banerjee (1987) reported that feed intake is stimulated by granulation of the feed. Birds fed on pellets consumed their feed in a shorter time than birds fed on mash. The physical form of these three feeds is not same. Most of the farmers purchase ready made feed, while others use farm made mash feed. From a comparative study by Christopher *et al.* (2006) between mash and pellet feed indicates that there is no economic difference between using either mashes or pellet feed. Further it was recommended that poultry growers can use any one of these depending on their preference. The crumble form of feed is better than mash and pellet for the production of commercial broiler (Jahan *et al.*, 2006). Broiler research in Bangladesh is focused mainly either on stocking density or feeding regime. However, in developed countries most of the broiler growers use environmental controlled house where stocking density can be compromised. Due to the environmental fluctuation, poultry production in tropical and sub-tropical countries suffers a lot. As about 99% commercial broilers are reared in simple open house; broiler rearing need appropriate management practice to improve its performance in Bangladesh (Saleque and

Rozen, 2007). Broiler growers need summer stocking density and feeding regime of broiler chicken to increase production and profitability of the broiler farm. Keeping this idea in mind the present study was undertaken with the following specific objectives:

- To determine the effect of stocking density and feeding regime on performance broiler chicken.
- To identify the suitable stocking density and feeding regime of broiler chicken during summer.
- To evaluate the carcass characteristics of broiler reared in summer season.
- To analyze the Benefit Cost Ratio (BCR) of broilers reared under different densities and feeding regimes.

Table 1: Layout of the experiment

Factors		Replications			
Density of bird/m^2	Feed	R1	R2	R3	R4
D$_1$ (8 bird/m^2)	F$_1$ (Mash)	M8	M8	M8	M8
	F$_2$ (Crumble)	C8	C8	C8	C8
	F$_3$ (Pellet)	P8	P8	P8	P8
D$_2$ (10 bird/m^2)	F$_1$ (Mash)	M10	M10	M10	M10
	F$_2$ (Crumble)	C10	C10	C10	C10
	F$_3$ (Pellet)	P10	P10	P10	P10
D$_3$ (12 bird/m^2)	F$_1$ (Mash)	M12	M12	M12	M12
	F$_2$ (Crumble)	C12	C12	C12	C12
	F$_3$ (Pellet)	P12	P12	P12	P12
D$_4$ (14 bird/m^2)	F$_1$ (Mash)	M14	M14	M14	M14
	F$_2$ (Crumble)	C14	C14	C14	C14
	F$_3$ (Pellet)	P14	P14	P14	P14

M indicates Mash feed; C indicates Crumble feed; P indicates pellet feed; M8 indicates 8 birds fed on mash feed

MATERIALS AND METHODS

Broiler chicks and management: A total of five-hundred and sixty (560) day-old straight run Cobb 500 chicks were used and fed on mash, crumble and pellet. The experiment was conducted at the Sher-e-Bangla Agricultural University Poultry Farm, Dhaka, Bangladesh for a period of six weeks. The conditions and standards of care employed in this experiment were in accordance with standard guideline of poultry management. In the layout of the experiment (Table 1) there were two factors, one was stocking density and another was feeds. The stocking densities were D$_1$ (8 bird/m^2), D$_2$ (10 bird/m^2), D$_3$ (12 bird/m^2) and D$_4$ (14 bird/m^2) and feeding regime which were F$_1$ (mash), F$_2$ (crumble) and F$_3$ (pellet).

The number of replication was four with 48 observations. The broiler chicks were housed in the open-sided south facing shed. To keep disease away from the broiler farm all bio-security measures such as Cleaning, washing, disinfection, common vaccination and medication were done. The experimental birds (528) distributed randomly inside the pens on the basis of stocking density and type of feeds. The size of each pen was 1 m^2 (1m x 1m x 0.46m). The mash and crumble feed were used as

starter ration (ME kcal/kg 2998.48 and CP 22.82%) and mash, crumble and pellet feed as grower (ME kcal/kg 3088.59 and CP 21.05%) and finisher (ME kcal/kg 3287.53 and CP 20.21%) ration. Feed and drinking water were allowed *ad libitum*. Round plastic feeders and drinkers were used. The average summer temperature and humidity at bird level was 31.9°C and 78% respectively. Fresh, clean and sun dried rice husk was used as shallow litter on floor. Using electric brooders did brooding. There was provision of cross net wire ventilation in the broiler house to remove polluted air. Thick polythene sheet was used over the net to save the bird from rains and wind. Electric fans were used as per necessity to save the birds from the summer heat stress. At night-light was provided with four 40 watt tubes light to eat and drink for first 2 weeks. Rest of the weeks 1 h dark was allowed at night in two times.

Data collection: Data were collected for initial body weight, temperature, humidity, feed intake, water intake, body weight gain, mortality and final live weight and carcass parts: breast, thigh, drumstick, wings, back, giblet and abdominal fat weight.

Dressing of broilers: Two birds were picked up at random from each replicate and sacrificed to estimate dressing percent and weight of breast, thigh, drumstick, back, neck, wing, giblet and abdominal fat. All birds to be slaughtered were weighed and fasted for over night (12 h). Birds were slaughtered following Halal method (Singh and Sharma, 2003). As per procedure the birds were defeathered, eviscerated. Thereafter the eviscerated carcass cut into parts.

Lab and economic analysis: Commercial ready made mash, crumble and pellet feeds were collected from feed mill and analyzed in the Bangladesh Livestock Research Institute (BLRI) laboratory to determine its proximate component. The economics was analyzed to find out benefit cost ratio/m^2 of broiler chicken by considering stocking density and type of feeds. The capital expenditure, recurring expenditure and depreciation cost were considered to calculate replication wise total annual expenditure. Finally replication wise benefit cost ratio was found by deducting the total expenditure from the total income according to treatment wise.

Following formula were used to find out different parameters:

$$\text{Feed consumption (g/bird)} = \frac{\text{Feed intake in a replication}}{\text{No. of live birds in a replication}}$$

$$\text{Water intake (ml/bird)} = \frac{\text{Water intake in a replication}}{\text{No. of live birds in a replication}}$$

$$\text{FCR} = \frac{\text{Feed intake (g)/bird}}{\text{Live weight (g)/bird}}$$

$$\text{Mortality (\%)} = \frac{\text{No. of death bird in a replication}}{\text{No. of initial birds in a replication}} \times 100$$

$$\text{BCR} = \frac{\text{Total income/}m^2}{\text{Total cost of production/}m^2}$$

Dressing yield = Live weight - (blood + feathers + head + shank+ digestive system)

$$\text{Dressing \%} = \frac{\text{Dressing yield}}{\text{Live weight}} \times 100$$

$$\text{Percent carcass cut} = \frac{\text{Carcass cut weight (g)}}{\text{Eviscerated weight (g)}} \times 100$$

Giblet weight = weight of liver + heart + gizzard + neck

Statistical analysis: Data were analyzed in factorial experiment with Randomized Completely Block Design (RCBD) for ANOVA table. MSTAT-C (Russel, 2004) computer package program was used for data analysis. Duncan Multiple Comparison Range Tests were done at 5% level of significant. Excel Program was practiced for preliminary data calculation.

RESULTS AND DISCUSSION

The average impartment performance parameters such as feed consumption, live weight, Feed Conversion Ratio (FCR), water consumption, mortality and Benefit Cost Ratio (BCR) data of 42 days of broiler chicken are presented in the Table 2, 3 and 4 respectively.

Feed consumption: The data of Table 2 shows the lower stocking density D_1 consumed significantly (p<0.05) highest amount of feed (4466 g/bird), where as the higher stocking density D_4 consumed least amount of feed (4307 g). There was a pattern of decreasing feed intake with the increasing of stocking density. This was due to less feeder space and immovability of birds within the pen and less ability of birds to express normal postural adjustments and to access feed. Several authors agreed that the feed consumption diminished with increasing stocking density (Scholtyssek and Gschwindt, 1983; Valdivie and Dieppa, 2002; Singh and Sharma, 2003; Thomas *et al.*, 2004; Santos *et al.*, 2005) which is similar to the present findings. The relationship between weekly feed intake and temperature is shown in Fig. 1. There was no remarkable change in feed intake with temperature up to 4 weeks, but at 5th week when temperature decreased then feed intake increased and at 6th week when temperature increased then feed intake decreased.

Table 2: Production performances of broiler chicken at different stocking densities in summer season

Density (No. of Bird/m^2)	Feed consumption (gm)/bird	Live weight (gm)/bird	Feed Conversion Ratio (FCR)	Water consumption (ml)/bird	Mortality (%)	Benefit Cost Ratio (BCR)/m^2
D$_1$ (8 bird/m^2)	4466[a]	2174[c]	2.09[a]	14010[a]	2.08	1.06[b]
D$_2$ (10 bird/m^2)	4430[a]	2160[c]	2.08[a]	13340[b]	2.50	1.05[b]
D$_3$ (12 bird/m^2)	4425[a]	2306[a]	1.95[b]	13160[c]	2.77	1.13[a]
D$_4$ (14 bird/m^2)	4307[b]	2252[b]	1.94[b]	13030[d]	1.78	1.12[a]
Mean±SE	4406.83±19.69	2223.27±14.72	2.01±0.0182	13383.52±26.17	2.28±1.285	1.09±0.0129
LSD$_{0.05}$	62.98	47.11	0.05841	83.74	4.111[NS]	0.04130
CV (%)	1.11	3.15	2.62	1.32	196.55	3.71

Means within a column with different superscripts are significantly different (p<0.05). Means within a column with same superscripts or without superscripts don't differ (p<0.05) significantly. SE = Standard Error, LSD = Least Significant Difference, CV = Coefficient of Variation, NS = Non Significant

Table 3: Production performances of broiler chicken at different feeding regime (Feed form) in summer season

Feeding Regime (Form of feeds)	Feed consumption (gm)/bird	Live weight (gm)/bird	Feed Conversion Ratio (FCR)	Water consumption (ml)/bird	Mortality (%)	Benefit Cost Ratio (BCR)/m^2
F$_1$ (Mash)	4342[c]	2224	2.02[ab]	13430	2.29	1.10
F$_2$ (Crumble)	4462[a]	2248	1.98[b]	13320	2.44	1.09
F$_3$ (Pellet)	4417[b]	2197	2.04[a]	13400	2.11	1.08
Mean±SE	4406.83±12.22	2223.27±17.51	2.01±0.01369	13383.52±44.08	2.28±1.123	1.09±0.0111
LSD$_{0.05}$	35.67	51.10[NS]	0.03997	128.7[NS]	3.279[NS]	0.03263[NS]
CV (%)	1.11	3.15	2.62	1.32	196.55	3.71

Means within a column with different superscripts are significantly different (p<0.05). Means within a column with same superscripts or without superscripts don't differ (p<0.05) significantly. SE = Standard Error, LSD = Least Significant Difference, CV = Coefficient of Variation, NS = Non Significant

Table 4: Production performances of broiler chicken at different 'density x feed' interaction groups in summer season

Density x Feed (Interaction)	Feed consumption (gm)/bird	Live weight (gm)/bird	Feed Conversion Ratio (FCR)	Water Consumption (ml)/bird	Mortality (%)	Benefit Cost Ratio (BCR)/m^2
D$_1$F$_1$	4455[ab]	2282[bc]	1.98[cde]	14230[a]	3.12	1.11[ab]
D$_1$F$_2$	4484[a]	2116[d]	2.15[a]	13930[b]	3.12	1.03[d]
D$_1$F$_3$	4458[ab]	2125[d]	2.13[ab]	13860[b]	0.00	1.06[bcd]
D$_2$F$_1$	4394[bc]	2178[cd]	2.05[bc]	13320[cd]	2.50	1.07[bcd]
D$_2$F$_2$	4509[a]	2184[cd]	2.10[ab]	13170[de]	2.50	1.06[bcd]
D$_2$F$_3$	4386[bc]	2119[d]	2.10[ab]	13530[c]	2.50	1.04[cd]
D$_3$F$_1$	4291[de]	2185[cd]	1.99[cd]	13140[de]	0.00	1.10[abc]
D$_3$F$_2$	4495[a]	2432[a]	1.87[f]	13160[de]	4.10	1.18[a]
D$_3$F$_3$	4490[a]	2302[b]	1.98[cde]	13170[de]	4.10	1.12[ab]
D$_4$F$_1$	4228[e]	2252[bc]	1.90[ef]	13030[de]	3.50	1.13[ab]
D$_4$F$_2$	4359[cd]	2262[bc]	1.95[def]	13010[e]	0.00	1.13[ab]
D$_4$F$_3$	4332[cd]	2243[bc]	1.96[de]	13040[de]	1.78	1.12[ab]
Mean±SE	4406.83±24.44	2223.27±35.01	2.01±0.0273	13383.52±88.17	2.28±2.247	1.09±0.0223
LSD$_{0.05}$	71.34	102.2	0.07993	257.3	6.558[NS]	0.06527
CV (%)	1.11	3.15	2.62	1.32	196.55	3.71

Means within a column with different superscripts are significantly different (p<0.05). Means within a column with same superscripts or without superscripts don't differ (p<0.05) significantly. SE = Standard Error, LSD = Least Significant Difference, CV = Coefficient of Variation, NS = Non Significant

The type of feeds (Table 3) show that the F$_2$ (4462 g) group of birds consumed significantly (p<0.05) highest amount crumble feed from the lowest F$_1$ (4342 g) mash group and F$_3$ (4417 g) was intermediate. The interaction between density x feed at 42 days broiler chicken is presented in the Table 4. It was observed that among different density x feed interaction group the D$_2$F$_2$ (4509 g) consumed significantly (p<0.05) highest amount of crumble feed from other treatment groups and the D$_4$F$_1$ (4228 g) consumed the lowest amount of mash feed. It is clear that the lower density consumed the highest amount of crumble feed and the highest density consumed the lowest amount of mash feed. Bolton and Blair (1977), Choi *et al.* (1986), Jahan *et al.* (2006), Golian and Mirghelenj (2009) studied the performance of mash, crumble and pellet feeds as broiler diet. They found that the crumble group showed high trend of feed consumption compared with others. Similar findings reported by Mutetwa (2001), Lemme *et al.* (2006), Amerah *et al.* (2007), Brickett *et al.* (2007) and Sundu *et al.* (2008) by comparing pellet with mash feed. The opinion of Bolukbasi *et al.* (2005) was contrary that there was no effect of pellet and mash feed on feed consumption.
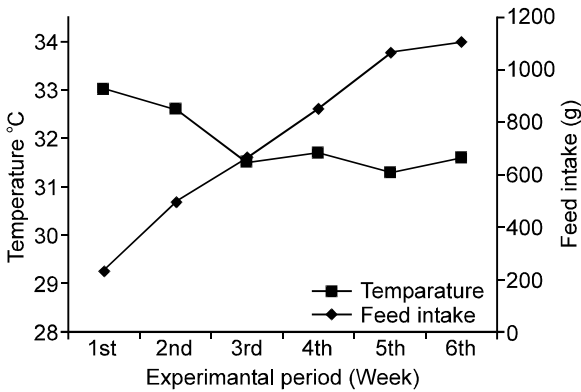
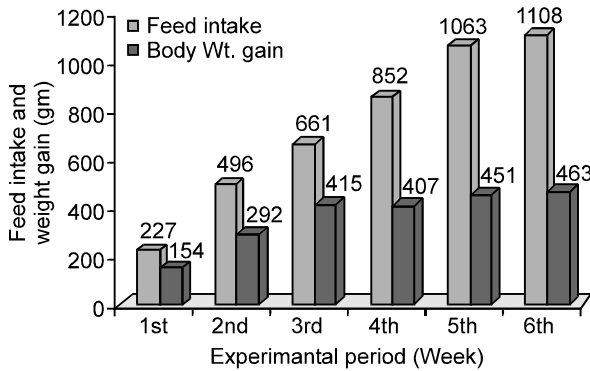Fig. 1: Weekly relationship between summer temperature and feed intake

Fig. 2: Weekly relationship between feed intake and weight gain in summer

Live weight: Table 2 states that the stocking density D_3 (2306 g) was significantly (p<0.05) higher from the stocking density D_4 (2252 g), D_1 (2174 g) and D_2 (2160 g) respectively. The lower stocking density D_1 and D_2 didn't show significant difference at final live weight. The stocking density D_3, 12 birds/m^2 showed better performance in achieving the final market weight. This findings directly supported by Mizubuti *et al.* (2000), Skrbic *et al.* (2007) and reported that the 12 birds/m^2 density showed higher (p<0.05) means for average body weight. Feddes *et al.* (2002) reported that body weight increased as density increased. Valdivie *et al.* (2004) proposed higher stocking density in Cuba to get higher live weight. Dozier *et al.* (2005) got findings that body weight was adversely affected by increasing the placement density above 30 kg of BW/m^2 (12 birds/m^2) of floor. Although El-Deek and Al-Harthi (2004) concluded that broiler chicks could be stocked up to 14 birds/m^2 without adverse effect on growth performance. The relationship between weekly feed intake and live weight gain is shown in Fig. 2. In 1st, 2nd and 3rd week minimum amount of feed was utilized to gain per unit live weight and at 4th, 5th and 6th week maximum amount of feed was utilized to gain per unit live weight.

According to type of feed (Table 3) no significant difference (p<0.05) was found among the F_1 (mash), F_2 (crumble) and F_3 (pellet) feed to achieve the final live weight 2224 g, 2248 g and 2197 g respectively, but F_2 (crumble) group of birds achieved the highest live weight. Table 4 indicates that the averge live weight of different `density x feed` interaction groups, among them D_3F_2 (2432 g) was significantly (p<0.05) higher from all other treatment groups. The D_1F_2 (2116 g) group was the lowest live weight achieved group. So here D_3F_2, 12 birds/m^2 fed on crumble feed was the best live weight gained group. McAllister *et al.* (2000) and Bölükbasi *et al.* (2005) also noted that feed type has no effect on live weight. But Jahan *et al.* (2006), Golian and Mirghelenj (2009) found effect of feed type on live weight and observed higher live weight from crumble and crumb-pelleted feed.

Feed conversion ratio (FCR): The average FCR value in Table 2 shows that the stocking density D_1 (2.09) and D_2 (2.08) were significantly (p<0.05) higher from D_3 (1.95) and D_4 (1.94). The FCR value of density D_4 and D_3 were significantly better (p<0.05) in comparison with the density D_1 and D_2. The Figure 3 shows weekly FCR value in comparison with age. The figure indicates that the feed efficiency was decreased after three weeks of age. The Lower FCR value indicates positive performance. Birds of lower density groups got chance to intake more feed, this more feed is one type of wastage because they didn't convert it into meat and finally unable to show better FCR value. It is evident from the result that feed conversion was better at the higher density than at the lower densities which is supported by Gonzalez *et al.* (1978a), Scholtyssek and Gschwindt (1983), Ravindran and Thomas (2004), Valdivie *et al.* (2004) and Sreehari and Sharma (2010).

It is revealed from Table 3 that FCR was affected by feeding regime. The better FCR was found in F_2 (1.98) from F_1 (2.02) and F_3 (2.04). But no significant difference (p<0.05) of FCR value was found in between F_1 (2.02) and F_2 (1.98) and F_1 (2.02) and F_3 (2.04). The crumble feed showed better efficiency than mash and pellet. The FCR value of most of the `density x feed` interaction groups differed significantly. Table 4 shows that the FCR value of D_1F_2 (2.15) group was significantly higher (p<0.05) from all other treatment groups. The FCR value of D_3F_2 (1.87) group was significantly lower (p<0.05) from all other treatment groups. The lowest FCR value of D_3F_2 indicates positive performance. The stocking density 12 birds/m^2 fed on crumble feed showed better feed efficiency. Reece *et al.* (1984), Jahan *et al.* (2006) carried out experiment on broiler feed and obtained better feed conversion ratio in crumble form of feed. Sarvestani *et al.* (2006) noted that pellet feed showed better FCR value than mash diet, similar findings reported by Golian and Mirghelenj (2009) who found better FCR in pellet feed compared to crumble-pellet and mash diet.
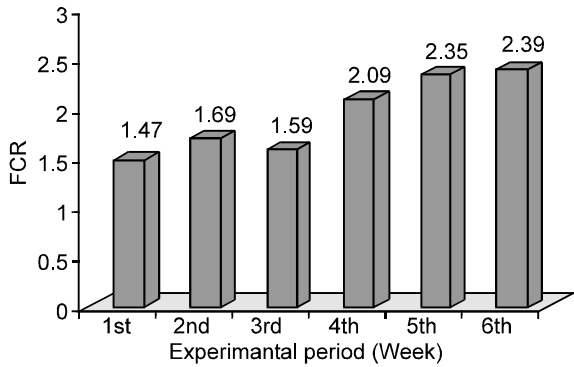
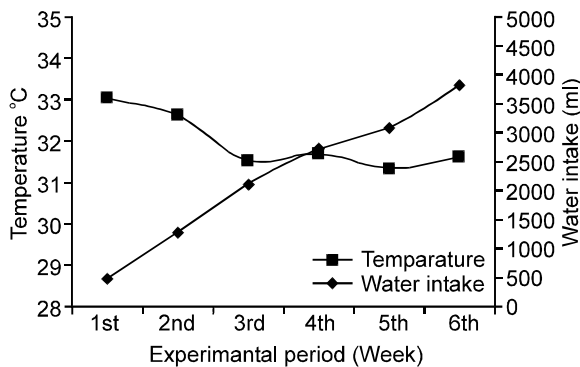Fig. 3: Relationship between FCR with age in summer

Fig. 4: Weekly relationship between summer temperature and water intake

Water consumption: The Table 2 indicates that the average water intake by all stocking densities were significantly differed (p<0.05) from each other. The highest amount of water was consumed by lower stocking density D_1 (14010 ml) followed by D_2 (13340 ml), D_3 (13160 ml) and D_4 (13030 ml). This is due to less locomotion of higher stocking birds to access drinker. Higher stocking density decreased bird movement (Andrews *et al.*, 1997). The maximum feed intake group D_1 consumed 3 times higher water than feed. Deaton *et al.* (1967) said that at higher density birds consumed less water. Feddes *et al.* (2002) reported that water consumption increases at higher stocking densities, although there was a trend toward a decrease in water intake with decreasing water nipple. The relationship between weekly water intake and temperature is shown in Fig. 4. There is no remarkable change in water intake with temperature up to 4 weeks, but at 5th week when temperature decreased then water intake also decreased and at 6th week when temperature increased then water intake increased.

Table 3 hints that there was no significant (p<0.05) difference in water consumption among F_1, F_2 and F_3 groups, although F_1 (mash) group of birds drank the highest amount (13430 ml) of water, that might be due

to crush or powder nature of mash feed. In Table 4, the most of the 'density x feed' interaction groups show significant (p<0.05) difference in water consumption. The water consumption of the D_1F_1 (14230 ml) group was significantly higher (p<0.05) from all other treatment groups and D_4F_2 (13010 ml) was the significantly lowest (p<0.05) water consumer group. This was due to less drinker space and immovability of birds within the pen. The 8 birds/m^2 fed on mash feed drank the highest amount of water and 14 birds/m^2 fed on crumble feed consumed the lowest amount of water.

Mortality: The mortality analysis data of broiler chicks is presented in Table 2, where the mean value of mortality was 2.28%. No significant (p<0.05) difference was found among different stocking density groups of D_1, D_2, D_3 and D_4. Most of the death occurred after 4 weeks of age and were sudden death. This might be due to summer heat stroke. The result confirmed that the stocking density had no effect on mortality among different densities. This finding is an agreement with Chew (1978), Gonzalez *et al.* (1978b), Offiong *et al.* (2001), Feddes *et al.* (2002), Hadorn *et al.* (2002), Thomas *et al.* (2004) and Meluzzi *et al.* (2008).

Table 3 shows no significant (p<0.05) difference in mortality among different feed types of F_1 (mash), F_2 (crumble) and F_3 (pellet) feed group of birds. This was possible due to proper bio-security measures of the broiler flock. Table 4 indicates mortality of different density x feed interaction groups where mean value is 2.28%, but no significant difference (p<0.05) was found. Jahan *et al.* (2006) also found non-significant (p<0.01) findings in mortality for mash, crumble and pellet feed.

Benefit Cost Ratio (BCR): The average Benefit Cost Ratio (BCR) data of different stocking density groups shown in Table 2, which varied from 1.05 to 1.13. The benefit cost ratio was affected by different stocking densities. Higher density showed maximum benefit. Although there was no significant (p<0.05) difference between higher density D_3 (1.13) and D_4 (1.12). The maximum benefit was found in the density of 12 birds/m^2. It is evident that the profit margins increased as stocking density increased and this findings agreed by Diego *et al.* (1995), Oliveira *et al.* (2000), Miragliotta *et al.* (2002) and Moreira *et al.* (2004).

Table 3 represents the average Benefit Cost Ratio (BCR) of broiler chicken in different feeding regimes. No significant (p<0.05) difference was found among the F_1 (1.10) F_2 (1.09) and F_3 (1.08) feeds. The BCR data of different 'density x feed' interaction groups are presented in the Table 4. It is shown from the table that the BCR was significantly (P<0.05) affected by most of the density x feed interaction groups.

The BCR of D_3F_2 (1.18) was significantly (p<0.05) higher from all other treatment groups. The density D_1F_2 (1.03)

showed significantly (p<0.05) the lowest BCR value among all treatments. It is concluded that the density 12 bird/m^2 fed on crumble feed was the best profitable groups. Sreehari and Sharma (2010) also found best net profit in increased stocking density. Jahan *et al.* (2006) gave same statement that the crumble form of feed is better than mash and pellet form of feed. Koknaroglu and Atilgan (2007) reported that raising broiler in summer season is more sustainable that in winter.

Carcass yield (%) of dressed broiler: The average dressing percent and percent of important carcass parts such as breast weight, thigh weight, drumstick weight, wing weight, back weight, giblet weight and abdominal fat weight data of 42 days broiler chicken under different stocking densities is presented in the Table 5. The average dressing percent and percent of important carcass parts such as breast weight, thigh weight, drumstick weight, wing weight, back weight, giblet weight and abdominal fat weight data under different feeding regimes is presented in the Table 6.

Dressing percent: Table 5 shows the dressing percent of the stocking density D_1 (77.17%) and D_2 (76.08%) were significantly (p<0.05) higher from the density D_3 (74.83%) and D_4 (74.17%). The lower stocking density D_1 and D_2 showed higher dressing percent and higher stocking density D_3 and D_4 showed lower dressing percent. It is signified from the result that the dressing

percentage was lower in the higher stocking density. Singh and Sharma (2003), El-Deek and Al-Harthi (2004) searched out same findings about dressing percent. Although Ravindran and Thomas (2004) reported that carcass characteristics were unaffected by stocking density.

Table 6 indicates that there was no significant difference (p<0.05) in dressing percent found among F_1 (75.25%), F_2 (75.69%) and F_3 (75.75%), but the F_3 (pellet) feed performed the highest dressing percent and F_1 (Mash) lowest. Golian and Mirghelenj (2009) conducted an experiment to assess the effect of feed form on broiler performance and noticed that weight of carcass percentage was not affected by physical form of diets. On the other hand, Rajini *et al.* (1998) and Brickett *et al.* (2007) found better dressing percent in pellet feed than mash at 6 and 8 weeks of age (p<0.05).

Breast weight percent: The presented average breast weight values in Table 5 indicates that D_1 (32.50%), D_2 (33.00%), D_3 (32.42%) and D_4 (32.25%) had no significant (p<0.05) effect on breast meat production, but the highest breast weight percent was found in the lower stocking density D_2. Dozier *et al.* (2006) reported that increasing stocking density decreased breast tender weight. Many poultry scientists conducted experiment to find out the effect of stocking density on carcass characteristics of broiler and noted that stocking density had no effect on carcass characteristics of broiler

Table 5: Yield of broiler carcass parts (%) at different stocking densities in summer season

Density (No. of Birds/m^2)	Weight of carcass parts (%)							
	Dressing	Breast	Thigh	Drumstick	Wing	Back	Giblet	Abdominal fat
D_1 (8/m^2)	77.17[a]	32.50	15.67	12.50	10.17	17.08	9.58	2.08[b]
D_2 (10/m^2)	76.08[a]	33.00	15.58	12.42	10.50	16.75	9.25	2.08[b]
D_3 (12/m^2)	74.83[b]	32.42	15.83	12.75	10.25	16.67	9.66	2.58[a]
D_4 (14/m^2)	74.17[b]	32.25	15.50	12.92	10.25	16.58	9.58	2.50[a]
Mean±SE	75.56±	32.54±	15.64±	12.64±	10.29±	16.77±	9.52±	2.31±
	0.3405	0.3004	0.2639	0.2639	0.1000	0.1763	0.1848	0.1118
LSD$_{0.05}$	1.089	0.9611[NS]	0.8444[NS]	0.8444[NS]	0.3199[NS]	0.5640[NS]	0.5913[NS]	0.3577
CV (%)	1.27	3.48	3.84	4.61	6.43	3.82	7.53	17.65

Means within a column with different superscripts are significantly different (p<0.05). Means within a column with same superscripts or without superscripts don't differ (p<0.05) significantly. SE = Standard Error, LSD = Least Significant Difference, CV = Coefficient of Variation, NS = Non Significant

Table 6: Yield of broiler carcass parts (%) at different feeding regime in summer season

Feeding regime (Firm of feeds)	Weight of carcass parts (%)							
	Dressing	Breast	Thigh	Drumstick	Wing	Back	Giblet	Abdominal fat
F_1 (Mash)	75.25	32.69	15.56	12.81	10.38	16.63	9.18	2.31
F_2 (Crumble)	75.69	32.31	15.56	12.69	10.19	16.94	9.68	2.43
F_3 (Pellet)	75.75	32.63	15.81	12.44	10.31	16.56	9.68	2.18
Mean±SE	75.56±	32.54±	15.64±	12.64±	10.29±	16.77±	9.52±	2.31±
	0.2394	0.2834	0.1502	0.1458	0.1655	0.1743	0.1792	0.1022
LSD$_{0.05}$	0.6988[NS]	0.8272[NS]	0.4384[NS]	0.4255[NS]	0.4829[NS]	0.5087[NS]	0.5231[NS]	0.2982[NS]
CV (%)	1.27	3.48	3.84	4.61	6.43	3.82	7.53	17.65

Means within a column with different superscripts are significantly different (p<0.05). Means within a column with same superscripts or without superscripts don't differ (p<0.05) significantly. SE = Standard Error, LSD = Least Significant Difference, CV = Coefficient of Variation, NS = Non Significant

chicken (Feddes *et al.*, 2002; Ravindran and Thomas, 2004; Thomas *et al.*, 2004; Makowski *et al.*, 2005; Sreehari and Sharma, 2010).

Table 6 shows that the breast weight percent of F_1 (32.69%), F_2 (32.31%) and F_3 (32.63%) was not statistically significant (p<0.05), but mash feed showed the highest breast weight percent. Golian and Mirghelenj (2009) conducted an experiment to assess the effect of feed form on performance of broiler chicken and indicated that the breast weight was not affected by physical form of diets. Lemme *et al.* (2006) reported that breast meat production increased by mash and pelleted form of feed.

Thigh weight percent: In the Table 5 no significant difference (p<0.05) in thigh weight % was found among different stocking densities of D_1 (15.67%), D_2 (15.58%), D_3 (15.83%) and D_4 (15.50%), but the highest thigh meat % was found in the stocking density D_3, 12 bird/m^2. It is evident that thigh weight % was not significantly affected by stocking density. Offiong *et al.* (2001), Ravindran and Thomas (2004), Thomas *et al.* (2004), Sreehari and Sharma (2010) also noticed that the carcass characteristics were unaffected by stocking density.

The Table 6 shows that thigh weight % was unaffected (p<0.05) by the feeding regimes F_1 (15.56%), F_2 (15.56%) and F_3 (15.81%), but F_3 (pellet) feed showed the highest thigh weight percent. Golian and Mirghelenj (2009) found that thigh weight was not affected by physical form of diets. Sarvestani *et al.* (2006) concluded that the carcass characteristics were improved in pellet diets.

Drumstick weight percent: It is evident from the Table 5 that there was no significant difference (p<0.05) in drumstick weight % found among different stocking densities of D_1 (12.50%), D_2 (12.42%), D_3 (12.75%) and D_4 (12.92%), but the highest drumstick weight was found in the stocking density D_4 (14 bird/m^2). Several authors reported that the various carcass characteristics were not influenced by stocking density (Offiong *et al.*, 2001; Feddes *et al.*, 2002; Ravindran and Thomas, 2004; Thomas *et al.*, 2004; Makowski *et al.*, 2005; Sreehari and Sharma, 2010).

In Table 6 there was no significant difference (p<0.05) in drumstick weight % found among different feeding regimes of F_1 (12.81%), F_2 (12.69%) and F_3 (12.44%), but the highest drumstick weight percent was found in the F_1 (mash) feed. Golian and Mirghelenj (2009) stated that drumstick weight was not affected by feeds.

Wing weight percent: Table 5 shows the wing weight % at different stocking densities of D_1 (10.17%), D_2 (10.50%), D_3 (10.25%) and D_4 (10.25%) which were not statistically significant (p<0.05), but the highest wing weight % was found in stocking density D_2 (10 bird/m^2).

The wing weight was not affected by stocking density and similar result reported by Offiong *et al.* (2001); Ravindran and Thomas (2004); Thomas *et al.* (2004); Makowski *et al.* (2005); Sreehari and Sharma (2010).

In Table 6 the mean wing weight % at different feeding regimes of F_1 (10.38%), F_2 (10.19%) and F_3 (10.31%) were not statistically significant (p<0.05), but the highest wing weight percent was found in feeding regime F_1 (mash) feed. Golian and Mirghelenj (2009) found that carcass parts were not affected by physical form of diets.

Back weight percent: In Table 5 no significant difference (p<0.05) in back weight % was found among different stocking densities of D_1 (17.08%), D_2 (16.75%), D_3 (16.67%) and D_4 (16.58%), but the highest back weight % was found in stocking density D_1 (8 bird/m^2). Offiong *et al.* (2001); Ravindran and Thomas (2004); Thomas *et al.* (2004); Makowski *et al.* (2005); Sreehari and Sharma (2010) noted that various carcass characteristics were not influenced by stocking density. Table 6 shows no significant difference (p<0.05) in back weight % among different feeding regimes of F_1 (16.63%), F_2 (16.94%) and F_3 (16.56 %), but the highest Back weight percent was found in feeding regime F_2 (crumble) feed.

Giblet weight percent: The average giblet weight % presented in Table 5 at different stocking densities of D_1 (9.58%), D_2 (9.25%), D_3 (9.66%) and D_4 (9.58%) were not found statistically significant (p<0.05), but the highest giblet weight % was found in stocking density D_3 (12 bird/m^2). Yakubu *et al.* (2010), Jayalakshmi *et al.* (2009) reported same result that the giblets weight was not significantly (p<0.05) influenced by housing density. Offiong *et al.* (2001); Ravindran and Thomas (2004); Thomas *et al.* (2004) also found that stocking density had no effect on carcass yield percent.

The average giblet weight % shown in Table 6 at different feeding regimes of F_1 (9.18%), F_2 (9.68%) and F_3 (9.68%) were not statistically significant (p<0.05), but the highest giblets weight was found in F_2 (crumble) and F_3 (pellet) feeds than mash. Golian and Mirghelenj (2009) found that carcass parts were not affected by pellet, crumble or mash. Rajini *et al.* (1998) got contrary result in giblet weight for pellet feed.

Abdominal fat percent: Abdominal fat weight percent in the stocking density D_1 (2.08%) and D_2 (2.08%) shown in Table 5, were significantly (p<0.05) lower from the density D_3 (2.58%) and D_4 (2.50%). Higher stocking density resulted more abdominal fat deposition and this was due to less locomotion of broilers at higher density pens. But contrary opinion was that the abdominal fat content was not affected by stocking density (Dozier *et al.*, 2006; Alsobayel *et al.*, 2007 and Jayalakshmi *et al.*, 2009).
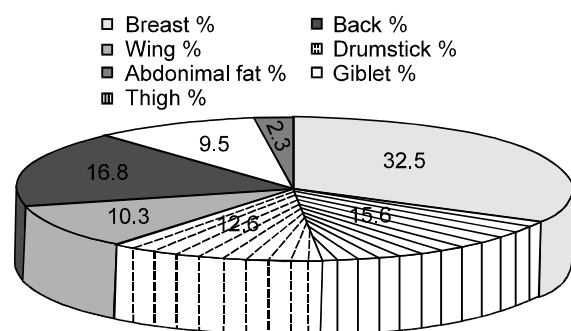
Fig. 5: Yield of broiler carcass percent of broiler chicken in summer

Table 6 indicates that there was no significant difference (p<0.05) in abdominal fat weight % found among different feeding regimes of F_1 (2.31%), F_2 (2.43%) and F_3 (2.18%). Golian and Mirghelenj (2009) observed no significantly (p<0.05) difference in abdominal fat weight by different form of feeds. Lemme *et al.* (2006) also observed decreasing fat accretion for all feed forms. The carcass yield % of different parts is presented in Fig. 5 and on the basis of % the carcass cuts can be ranked as 1. Breast (32.54%), 2. back (16.77%), 3. thigh (15.64%), 4. drumstick (12.64), 5. wing (10.29%), 6. giblet (9.5%) and abdominal fat (2.31).

The broiler chicken of lower stocking density group consumed the highest amount feed and water. But the birds of higher stocking density group fed on crumble feed showed better feed efficiency and achieved the highest live weight. The mortality was not affected either by density or feeds. The carcass parts were unaffected by stocking density and feeding regimes, but lower stocking density produced higher dressing percentage and lower abdominal fat. The highest profit margin was found in higher stocking density group fed on crumble feed. So, 12 birds/m^2 fed on crumble feed is suggestive for commercial broiler production in summer condition of Bangladesh rearing up to 6 weeks of age.

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