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Full Length Research Paper

Responses of two broiler chicken strains to early-age skip-a-day feed restriction in a semi-arid subtropical environment

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Four hundred and eighty 7-day-old Ross 308 and Hubbard chicks were fed *ad libitum* or full-fed every other day for 4, 6 and 8 days followed *by ad libitum* feeding to 49 days of age in a 2 x factorial experiment to study the effects of the different treatments on growth. The strains did not differ in feed conversion ratio and mortality rate but Ross 308 gained more weight and was heavier at market age but consumed more feed and deposited more abdominal fat. Overall, feed removal neither reduced feed intake and mortality rate nor improved feed efficiency but the control and the 4- and 6-day feed restricted birds had similar post-restriction weight gains and market weights and deposited more abdominal fat than the 8-day feed restricted ones. There was a significant strain × feeding regime interaction effects on 49-day weight and weight gain from 7 to 21 days. It is suggested that for profitable broiler production in the subtropics, Ross 308 be used and feed- restricted for 6 days during the starter period.

Key words: Broiler chicken strains, early-age skip-a-day feeding, growth performance subtropics.

INTRODUCTION

The growth rate and feed conversion of broiler chickens have improved dramatically in recent years due to improvements in nutrition and genetic selection. Along with these improvements have come correlated responses such as increased appetite. As a result, modern broiler chickens when given unlimited access to feed, tend to eat more than they require for maintenance and production, and the excess energy is converted into fat (Summers and Spratt, 2000; Richards et al., 2003; Cuddington, 2004), an uneconomical and undesirable product that not only causes obesity and metabolic diseases but also causes leg disorders in growing birds (Mattocks, 2002).

Feed accounts for about 70% of the cost of broiler production and this emphasizes the need to improve the efficiency of feed utilization. Furthermore, consumers are becoming increasingly aware of the effect of excessive carcass fat on human health and are demanding meat containing less fat (Hassanabadi and Moghaddam, 2006). The need to reduce carcass fat can therefore not be overemphasized. Various quantitative and qualitative feed restriction programmes have therefore been used in attempts to restrict feed intake, reduce feeding cost, carcass and abdominal fat resulting in incidence of metabolic diseases and improve feed efficiency (Tolkamp et al., 2005; Zhan et al., 2007).

The results of several studies have shown that early-age skip-a-day feed withdrawal followed by *ad libitum* feeding to market age reduces the above-mentioned problems. During the period of feed restriction, growth is slower in the feed-restricted birds than in birds fed *ad libitum* but reports on compensatory growth, mortality rate, feed efficiency and abdominal fat deposition have been conflicting (Dozier et al., 2002, 2003; Khajali et al, 2007; Mohebodini et al., 2009). However, these have been influenced by several factors including the severity and duration of restriction as well as strain of birds used

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Table 1. Chemical composition (Label values) of commercial broiler starter, grower and finisher feeds to be used in this study.

Composition (g/kg except ME)	Starter	Grower	Finisher
Crude protein	200.0	180.0	160.0
ME (MJ/kg)	2.76	13.00	13.20
ME:CP ratios (MJ g-1)	0.06	0.07	0.08
Fat	25.0	25.0	25.0
Fibre	50.0	60.0	70.0
Moisture	120.0	120.0	120.0
Calcium	12.0	12.0	120
Phosphorus	6.0	5.5	5.0
Lysine	12.0	0.0	9.0

*Supplied by Meadow Feeds, Randfontein, South Africa.

(Summers and Spratt, 2000; Doyle and Leeson, 2003). This study evaluated the effects of different durations of early-age skip-a-day feed removal periods on the growth performance of two strains of broiler chickens over a 49-day production period.

MATERIALS AND METHODS

Experimental procedure

This study which lasted 7 weeks was conducted at the poultry facility of the school of agriculture experimental farm, University of Venda, Thohoyandou, South Africa. The climate is subtropical with hot humid summers and cold dry winters. The ambient temperatures during the experimental period (15th April to 2nd June) ranged from 10 to 26°C with a mean of 18°C. Two hundred and forty male day-old chicks each of Ross 308 and Hubbard broiler strains were raised on a commercial starter diet from day-old to 21 days of age, grower diet from 21 to 35 days of age, and a finisher diet from 35 to 49 days of age (Table 1). The chicks were raised together to 6 days of age (acclimatization period). On day 7, the birds were randomly divided into 24 groups of 20 chicks each, leg-banded, individually weighed, and randomly allocated to 24 experimental pens measuring 1.50 × 2.85 m, thereby allowing 0.21 m^2 of floor space per bird. Each pen was equipped with two 175-watt infrared bulbs for heating and two tube feeders and two bell drinkers, allowing each bird 12.4 cm feeder space and 9.4 cm drinker space. The pens were assigned at random to the following treatments (three pens per strain-treatment combination):

1. *Ad libitum* feeding throughout the experimental period
2. *Ad libitum* feeding except for 24 h feed removals on 7, 9, 11, and 13 days of age
3. *Ad libitum* feeding except for 24 h feed removals on 7, 9, 11, 13, 15, and 17 days of age
4. *Ad libitum* feeding except for 24 h feed removals on 7, 9, 11, 13, 15, 17, 19 and 21 days of age.

These treatments are hereafter called ALC, R4, R6 and R8, respectively. Water was provided *ad libitum* and lighting was continuous. After the initial weighing, the birds were also weighed on days 21 and 49. Prior to each weighing, the birds were fasted for 12 h. Feed consumed in each pen was recorded when the birds were weighed. After the last weighing on day 49, four birds were randomly sampled from each pen. The selected birds were killed, defeathered and placed in polyethylene bags and chilled for 48 h after which they were thawed and the viscera, heads, necks and shanks were removed. Each carcass was then placed on its back, the thighs were separated and a slanted cut about 45° was made just under the keel to the back bone. Abdominal fat (fat surrounding the gizzard, rectum, cloaca and adjacent abdominal muscles) were removed and weighed. From these, the weights of the abdominal fat which are expressed as percentages of live weights were calculated.

Statistical analysis

Initial analyses showed that the strains differed significantly in initial body weight. The data were therefore analysed by analysis of covariance for a 2 × 4 factorial in a completely randomized design with initial body weight as the covariate, using Minitab 16 Statistical Package (Minitab Inc., 2010). Two strains and four skip-a-day feed withdrawal periods were tested. Statistical significance of differences among means was determined by Tukey’s Procedure (Steel and Torrie, 1981).

RESULTS

Performance during the feed restriction period (Table 2) shows that strain significantly influenced 21-day weight and weight gain (both at $p<0.05$) with Ross 308 performing better than Hubbard. Treatment affected 21-day weight, weight gain, feed intake and feed conversion ratio (all at $p<0.01$).The control birds consumed more feed than the feed-restricted birds which did not differ in feed intake. Also, the ALC and R4 birds gained more weight and were heavier at 21 days of age than the R6 and R8 birds ($P<0.05$); the R6 birds also performed better in these traits than the R8 birds. In addition, birds on the ALC, R4 and R6 treatments did not differ in feed conversion but utilized feed more efficiently than their counterparts on the R8 treatment (1.53, 1.55 and 1.61 *vs* 2.75g feed/g gain respectively).

During the post-restriction period (Table 3), strain affected 49-day weight and weight gain (both at $p<0.01$) as well as feed intake ($p<0.05$) but did not affect feed conversion ($p>0.05$). Ross 308 consumed more feed, gained more weight and was heavier at 49 days than

Table 2. Mean body weights, weight gain, feed intake and feed conversion ratio of full-fed and feed-restricted broiler strains during the restriction period (7 – 21 days of age) (N=3).

Strain	Treatment	Ibw (g)	W21(g)	Wg_{7-21} (g)	Fi (g/b/d)	Fcr (gf/gg)
Ross 308	ALC	164^{a}	656^{a}	507^{a}	58^{a}	1.44^{c}
	R4	162^{a}	643^{ab}	494^{a}	48^{b}	1.24^{c}
	R6	162^{a}	542^{bcde}	393^{abc}	35^{b}	1.17^{c}
	R8	162^{a}	385^{f}	236^{d}	48^{b}	2.89^{a}
Hubbard	ALC	146^{b}	572^{abc}	423^{ab}	48^{b}	1.61^{bc}
	R4	131^{c}	478^{cdef}	329^{bcd}	41^{b}	1.85^{abc}
	R6	134^{c}	$419d^{ef}$	269^{cd}	39^{b}	2.05^{abc}
	R8	132^{c}	369^{f}	220^{d}	40^{b}	2.61^{ab}
SEM		4.3	25.6	25.6	3.1	0.214
Strain means						
Ross 308		162^{a}	557^{a}	408^{a}	47^{a}	1.69^{a}
Hubbard		136^{b}	460^{b}	310^{b}	42^{a}	2.03^{a}
SEM		2.1	12.8	12.8	1.6	0.107
Treatment means						
ALC		155^{a}	614^{a}	465^{a}	53^{a}	1.53^{b}
R4		147^{a}	561^{a}	412^{a}	44^{b}	1.55^{b}
R6		148^{a}	481^{b}	331^{b}	37^{b}	1.61^{b}
R8		147^{a}	377^{c}	228^{c}	44^{b}	2.75^{a}
SEM		3.0	15.6	15.4	2.2	0.151
Strain (S)		**	*	*	NS	NS
Treatment (T)		NS	**	**	**	**
S x T		NS	NS	NS	NS	NS

Ibw = initial body weight; W_{21} = weight at 21 days of age; Wg_{7-21} = Weight gain from 7 to 21 days of age; Fi = Feed intake; Fcr = Feed conversion ratio, g/b/d = grams/ bird/day; gf/gg = grams feed /gram gain. Within each column, means carrying the same superscripts are not significantly different at p< 0.05. SEM= standard error of means. NS = Not significant; * p<0.05; ** P< 0.01.

Hubbard but the strains were similar in feed conversion (p>0.05). Birds on all treatments consumed similar quantities of feed but birds on the ALC, R4 and R6 treatments gained more weight and were heavier at 49 days of age than those on the R8 treatment. Also, the feed-restricted birds utilized feed more efficiently than the ALC birds. Additionally, strain × treatment interaction had a significant effect on 49-day weight (p<0.05).

Over the entire experimental period (Table 4), strain influenced weight gain and final body weight (both at p <0.01) as well as feed intake and abdominal fat percentage (both at p<0.05) but did not affect feed conversion ratio and mortality rate (P>0.05). Ross 308 had higher feed intake, weight gain and market weight and deposited more abdominal fat than Hubbard. Treatment influenced weight gain, 49-day weight and abdominal fat percentage (all at p<0.01) but did not affect feed intake, feed conversion ratio and mortality rate (p>0.05). Birds on all treatments consumed similar quantities of feed, utilized the feed with the same degree of efficiently and had similar mortality rates; however, birds on the ALC, R4 and R6 treatments gained more weight, were heavier at 49 days and deposited more abdominal fat than those on the R8 treatment.

DISCUSSION

The superior performance of Ross 308 than Hubbard in 21-day weigh and weight gain during the restriction period has been reported in similar studies by Bruggman et al. (2005), Rosa et al. (2007). Plavnik and Balnave (1992) and Dozier et al. (2003), however, restricted the feed intake of different strains of broilers for 7 and 5 days respectively during the starter period and reported insignificant differences among strains in response to feed restriction. Such discrepancies may be due to the different strains of birds used in the various investigations (Gous et al., 1999; Mahmood et al., 2005). The fact that Ross 308, despite the adjustments in the data for difference in initial body weight of the strains as well as similarities in feed intake and feed conversion gained

Table 3. Mean body weight, weight gain, feed intake and feed conversion ratio of full-fed and feed-restricted broiler strains during the post-restriction period (21 - 49 days of age) (N=3).

Strain	Treatment	W_{49} (g)	Wg_{21-49} (g)	Fi (g/day)	Fcr (gf/gg)
Ross 308	ALC	3058^{a}	2409^{ab}	196^{a}	2.34^{a}
	R4	3103^{a}	2469^{ab}	185^{ab}	2.12^{a}
	R6	3062^{a}	2514^{a}	174^{abc}	1.96^{ab}
	R8	2687^{b}	2310^{b}	172^{abc}	2.09^{ab}
Hubbard	ALC	2492^{bc}	1918^{c}	164^{abc}	2.41^{a}
	R4	2511^{bc}	2007^{c}	127^{c}	1.81^{b}
	R6	2480^{c}	2052^{c}	145^{bc}	2.00^{ab}
	R8	2317^{c}	1936^{c}	145^{bc}	2.15^{a}
SEM		39.9	44.0	9.9	0.122
Strain means					
Ross 308		2977^{a}	2426^{a}	182^{a}	2.11^{a}
Hubbard		2450^{b}	1978^{b}	145^{b}	2.09^{a}
SEM		20.0	16.8	4.9	0.061
Treatment means					
ALC		2775^{a}	2163^{bc}	180^{a}	2.34^{a}
R4		2807^{a}	2238^{ab}	156^{a}	1.96^{b}
R6		2771^{a}	2283^{a}	160^{a}	1.98^{b}
R8		2502^{b}	2123^{c}	159^{a}	2.12^{ab}
SEM		28.2	23.6	7.0	0.086
Strain (S)		**	**	*	NS
Treatment (T)		**	**	NS	*
S x T		*	NS	NS	NS

W49 = weight at 49 days of age; Wg21-49 = Weight gain from 21 to 49 days of age; Fi = Feed intake; Fcr = Feed conversion ratio, g/b/d = grams/ bird/day; gf/gg = grams feed /gram gain. Within each column, means carrying the same superscripts are not significantly different at p< 0.05. SEM= standard error of means. NS = Not significant; * p<0.05; ** P< 0.01.

more weight and was heavier than Hubbard suggests that the higher weight gain and heavier 21-day weight of Ross 308 are probably due to genetic differences in growth rate and body weight. Positive genetic correlations exist among body weight, growth rate and feed consumption (Chambers, 1990; Aggrey et al., 2005). Therefore, one would expect Ross 308 on account of its faster growth rate to consume more feed. The faster weight gain and heavier 21-day weight of Ross 308 than Hubbard despite the similarities in feed intake also suggests that Ross 308 converted feed more efficiently than Hubbard though the difference was not statistically significant. The control birds consumed more feed than all the feed-restricted ones as expected but birds on the various restricted-feeding treatments consumed similar quantities of feed. Also, the ALC and R4 birds gained more weight and were heavier at 21 days of age than the R6 and R8 birds and the R6 birds in turn performed better in these traits than the R8 birds (p<0.01). Several authors have reported reduced weight gain, feed intake and body weight (Mahmood et al., 2007; Mohebodini et al., 2009; Novel et al., 2009) and improved feed conversion (Dozier et al., 2003; Navidshad et al., 2006) in feed-restricted than in full-fed birds. The absence of any differences in feed consumption among birds on the various restricted feed treatments is quite unusual. One would have expected a progressive reduction in feed intake with the increasing duration of feed restriction as was reflected in weight gain from 7 to 21 days of age and 21-day weight. The reason for this is difficult to explain. One could only guess that when birds on restricted-feeding regimes were returned to full feeding, they consume enough feed to compensate for the decreased feed intake during the period of restriction. The observation that the birds whose feeding time was reduced by 4 days consumed similar quantities of feed as the other feed-restricted birds but gained weight similarly and had a similar 21-day weight as the control birds and was better than the other feed-restricted birds suggests that reducing feeding time by 4 days had no harmful effects on the birds whilst reducing feeding time by 6 or 8 days did. Also, the fact that the birds which were feed-restricted by 8 days, had the worst feed conversion ratio, gained the least weight and were the lightest at 21 days

Table 4. Weight gain, feed intake, feed conversion ratio, mortality rates and abdominal fat percentage of full-fed and feed-restricted broiler strains during the entire study period (7 - 49 days of age) (N=3).

Strain	Trt.	Wg7-49 (g/day)	Fi (g/day)	Fcr (gf/gg)	Mr (%)	Af (%)
Ross 308	ALC	2919^{a}	149^{a}	2.15^{a}	5.9^{a}	2.67^{a}
	R4	2965^{a}	138^{ab}	1.97^{a}	10.5^{a}	2.74^{a}
	R6	2906^{a}	127^{abc}	1.84^{a}	7.1^{a}	2.51^{ab}
	R8	2548^{b}	130^{abc}	2.14^{a}	5.5^{a}	2.11^{ab}
Hubbard	ALC	2342^{c}	125^{abc}	2.25^{a}	4.5^{a}	2.45^{ab}
	R4	2349^{c}	98^{c}	1.78^{a}	3.6^{a}	2.54^{ab}
	R6	2321^{c}	109^{c}	1.99^{a}	4.2^{a}	2.00^{ab}
	R8	2156^{d}	110^{c}	2.19^{a}	2.0^{a}	1.78^{b}
SEM		40.6	7.2	0.121	3.7	0.166
Strain means						
Ross 308		2834^{a}	136^{a}	2.02^{a}	7.2^{a}	2.51^{a}
Hubbard		2291^{b}	110^{b}	2.05^{a}	3.6^{a}	2.19^{b}
SEM		20.3	3.6	0.060	1.8	0.083
Treatment means						
ALC		2630^{a}	137^{a}	2.20^{a}	5.2^{a}	2.56^{a}
R4		2657^{a}	118^{a}	1.88^{a}	7.1^{a}	2.64^{a}
R6		2613^{a}	118^{a}	1.92^{a}	5.6^{a}	2.25^{ab}
R8		2352^{b}	120^{a}	2.16^{a}	3.8^{a}	1.94
SEM		28.7	5.1	0.08	2.6	0.188
Strain (S)		**	*	NS	NS	*
Treatment (T)		**	NS	NS	NS	**
S x T		NS	NS	NS	NS	NS

Wg7-49 = Weight gain from 7 to 49 days of age; Fi = Feed intake; Fcr = Feed conversion ratio, Mr = Mortality rate; Af= abdominal fat; g/b/d = grams/ bird/day; gf/gg = grams feed /gram gain. Within each column, means carrying the same superscripts are not significantly different at p< 0.05. SEM= standard error of means. NS = Not significant; * p<0.05; ** P< 0.01.

of age suggests that eight days of early feed restriction had a more detrimental effect on the bird than feed restriction for 6 days. The fact that the ALC, R4 and R6 birds did not differ in feed efficiency, supports some earlier reports (Dozier et al., 2002; Khajali et al., 2007) that feed restriction has insignificant effects on feed intake and efficiency but is contrary to other findings that feed restriction improved feed efficiency in feed-restricted than full-fed birds (Dozier et al., 2003; Navidshad et al., 2006). The poorer feed utilization of birds on the R8 treatment than those on the R4 and R6 treatments is also at odds with an earlier report by Mahmood et al. (2005) that the longer the period of restriction the better the efficiency of feed restriction.

The higher feed intake, faster growth and heavier market weight of Ross 308 than Hubbard during the post-restriction period despite the similarity in feed conversion ratio suggests that Ross 308 is superior to Hubbard in post-restriction growth rate and final body weight but needs more feed to maintain this superiority as suggested by the positive genetic correlations among feed intake, growth rate and body weight. The superiority of Ross 308 over Hubbard in these traits has also been reported in an earlier study by Benyi et al. (2011). Also, the fact that the birds whose feeding times were reduced by 4 and 6 days converted feed more efficiently, gained more weight than the *ad libitum* controls and had similar 49-day weights as the controls suggests that the 4- and 6-day feed-restricted birds had compensatory growth during realimentation. The inability of the 8-day feed restricted birds to attain similar weight gain and 49-day weight as the *ad libitum* controls despite similarities in feed intake and superior feed conversion than the control birds during the period of resumed full feeding supports our earlier suggestion that 8 days of skip-a-day feed withdrawal had such a detrimental effect on the birds that they were unable to catch-up with ALC, R4 and R6 birds. The results also show strain × feeding regime interaction effects on 49-day weight. In Ross 308, birds that were fed *ad libitum* and those whose feeding times were reduced by 4 and 6 days did not differ in weight gain but performed better in this trait than those that were feed-restricted for 8 days; in Hubbard, however birds on all treatments had similar 49-day weights. A similar result was obtained on post-restriction weight gain but the interaction was not statistically significant. This suggests that genotype × environment interaction measured in this study as strain × feeding regime interaction may have important influences on mature body weight and probably weight gain but not on other traits. Benyi et al. (2011) reported significant strain × feeding regime interactions effects on 35-day weight, weight gain and feed intake.

The significant differences between the strains in feed intake, growth rate and market weight during the entire study period have been previously reported (Rosa et al., 2007) but other authors such as Dozier et al. (2003) reported insignificant differences among strains of broilers in response to skip-a-day feed restriction. The similar feed utilization of Ross 308 and Hubbard observed in this study supports similar reports by Dozier et al. (2003) and Khajali et al. (2007) but is contrary to an observation by Ghazanfari et al. (2010) that skip-a-day feed restriction improved feed efficiency. The insignificant difference between the strains in mortality rate suggests that perhaps the durations of restriction used in this study were not long enough to cause differences between the strains. The higher abdominal fat in Ross 308 than Hubbard supports similar observations by Santos et al. (2005). A positive genetic correlation ranging from 0.21 to 0.36 exists between live weight and abdominal fat percentage (Chambers, 1990) therefore the significantly higher abdominal fat deposition by Ross 308 than Hubbard is to be expected on account of its heavier final live weight (2848 *vs.* 2278 g).

The birds whose feeding times were reduced by 4 or 6 days consumed similar quantities of feed and utilized the feed as efficiently as those on the other treatments. In addition, these birds gained weight equally and had similar market weights as the control birds; birds on the 8-day feed restriction programme gained less weight and were lighter at market age. This suggests that skip-a-day feed removal for 4 or 6 days during the starter period was not as harmful to the birds as feed removal for 8 days. Dozier et al. (2002, 2003) and Khajali et al. (2007) stated that broiler chickens are able to compensate for loss of weight resulting from short periods of feed restriction at early age but complete growth compensation becomes unlikely as the period of under-nutrition increases. These authors reported that 2, 3 or 4 days of skip-a-day feed removal was not very harmful and therefore the birds were able to regain the weight losses incurred during the restriction period and attain the same market weights as their *ad libitum* controls; however, 5 or 6 days feed removal was too long and did allow the birds enough time to recover from the weights lost during the restricted-feeding period. In our case, birds whose feeding time was reduced by 4 or 6 days between 7 and 21 days of age were able to recover the weight losses incurred during the period of feed restriction and have the same market weights as their counterparts which were fed *ad libitum* throughout this study. Benyi et al. (2011) reported that 6 days of feed withdrawal during the starter period was not too devastating to the birds and allowed them enough time to regain the weight losses incurred during restriction but birds that were deprived of feed every other day for 10 or 14 days could not recover the weight losses.

The overall results of this study show that the strains used in this study did not differ in mortality rate and feed conversion ratio but Ross 308 gained more weight and was heavier at market age but consumed more feed and deposited more abdominal fat than Hubbard. In addition, birds on all the treatments consumed similar quantities of feed, utilized the feed with the same degree of efficiency and had similar mortality rates but birds that were fed *ad libitum* or were denied feed for 4 or 6 days gained more weight and were heavier at 49 days of age but deposited more abdominal fat than those whose feeding time was reduced by 8 days. This suggests that reducing feeding time by 8 days between 7 and 21 days of age was probably too long and therefore the period of restored full feeding was too short to allow complete recovery of body weight loss. The results also indicate significant strain × feeding regime interaction effects on 49-day weight during the post-restriction period and suggests that genotype × environment interaction measured as strain × feeding regime interaction in this study may have important influences on body weight but not on other traits. It is suggested that for profitable broiler production in the tropics and subtropics, Ross 308 could be used and subjected to skip-a-day feed restriction for 6 days during the starter period.

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