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# Effects of a qualitative feed restriction strategy on the growth performance and feed cost of mature broiler chicken

**N.S.B.M. Atapattu and W.C.J. Chandrasiri**
*Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya*
✉ *nsbm@ansci.ruh.ac.lk*

**Abstract**
Early growth retardation in broiler chicks induces an accelerated growth known as compensatory growth, which results in final body weights equal or even exceeding that of the birds fed *adlibitum*. Objective of this study was to determine whether relatively mature broiler chicken posses the compensatory growth capacity after a qualitative feed restriction period (RF) and, to determine the effects of such a feeding strategy on growth performance and feed cost of mature broiler chicken. Thirty four days old broiler chicken (n=80) were allocated into twenty cages and the cages were randomly allocated into four dietary regimens. The dietary regimens were; 1) feeding of commercial broiler finisher diet (CF) from day 35 to 49, 2) feeding of above CF and a mixture of soy bean meal/maize meal 1:1 (SM11) in alternate days from 35-40 followed by *ad libitum* feeding of same CF until day 49, 3) same as regimen 2 except the use of soy bean meal/maize meal 1:2 mixture (SM12) between 35-40 d and 4) same as dietary regimen 2 except for the use of soy bean meal/maize meal 2:1 mixture (SM21) from 35-40 d. The total CF intake of the birds subjected to RF was significantly ($p<0.05$) lower than those who offered CF uninterruptedly. The live weight on day 40 and the weight gain from 35-40 d were significantly ($p<0.01$) reduced when SM mixtures were given from 35-40 d. Interestingly, the weight gain from 41-49 was significantly higher for the birds who received SM11 during from 35-40 than those who received CF uninterruptedly. The total live weight gain and the feed conversion ration (FCR) of the birds subjected RF were not significantly different from the birds in feeding regimen 1. The total feed cost per kg of live weight gain of the birds who received CF throughout reduced by 19 Rs when the second dietary regimen was adopted. It was concluded that mature broiler chicken also show compensatory growth capacity following a qualitative feed restriction and that capacity could be used to reduce the feed cost without performance being negative affected.

*Keywords:* Restricted feeding, Broiler, growth

## Introduction

Compensatory growth is defined as the abnormally rapid growth of an animal after early growth retardation resulting due either to qualitative or quantitative feed restriction. Studies of Plavnik and Hurwitz, 1985, 1991 and Plavnik et al., 1988) showed that when broilers were given *ad libitum* feeding following an early feed restriction, the final live weights were similar to that of full-fed counterparts. Also, the carcass and abdominal fat contents were also reduced when birds were subjected to restricted feeding strategies. Some studies, for example, Washburn and Bondari, (1978) and Plavnic and Hurwitz (1988) have shown that feed restriction strategies could be used to improve the feed efficiency as well.

However, some feed restriction studies have failed to prove beneficial effects in relation to growth performance (Ballay et al., 1992; Yu et al., 1990; Boa-Amponsem 1991; Su et al., 1999; Yu et al., 1990; Kuhn et al., 1996; Buys et al., 1998) and fat deposition (Plavnik et al., 1985; Summer et al., 1990; Yu et al., 1990). A number of recent studies have shown that restricted feeding strategies could be helpful to reduce the metabolic disorders such as ascites (Acar et al., 1995; Buys et al., 1998; Balog et al., 2000) and leg weaknesses (Su et al., 1999; Carter et al., 1994; Robinson et al., 1992).

The method, severity and the timing of feed restriction and the length of the *ad libitu* periods studied vary widely. In many of the restricted feeding studies reported in literature, birds have been subjected to feed restriction during early ages. Restriction feeding studies done with mature broiler chicken are limited. Balog et al. (2000) did not find compensatory growth capacity in mature broilers who subjected to a severe quantitative feed restriction We hypothesize that the

severity of feed restriction they used was so severe and thus birds might not have caught up the growth during subsequent ad libitum feeding period. Broilers spend around 22% of their time budget on feeding (Prayitno et al., 1997). Therefore quantitative feed restriction strategies such as feed withdrawal may not be justified on ethical ground. In this circumstances, it is suggested that mild qualitative feed restriction strategy would induce compensatory growth in mature broiler chicken. Objective of this study was to determine whether relatively mature broiler chicken posses the compensatory growth capacity after a qualitative feed restriction period (RF) and, to determine the effects of such a feeding strategy on growth performance and feed cost of mature broiler chicken.

**Materials and Methods**

Day old broiler chicks were obtained from a commercial hatchery and brooded in an electrically heated brooder for two weeks. Until day 21, chicks received a commercial broiler starter diet and a commercial finisher diet thereafter (Table 1). On day thirty four broiler chicken (n=80) were allocated into twenty cages and the cages were randomly allocated into four dietary regimens so that each treatment have five replicate cages, each having four birds. The dietary regimens were; 1) feeding of commercial broiler finisher diet from day 35 to 49, 2) feeding of above CF and a mixture of soy bean meal/maize meal 1:1 (SM11) in alternate days from 35-40 followed by ad libitum feeding of same CF until day 49, 3) same as regimen 2, except the use of soy bean meal/maize meal 1:2 mixture (SM12) between 35-40 d and 3) same as dietary regimen 2 except for the use of soy bean meal/maize meal 2:1 mixture (SM21) from 35-40 d. Water was given ad libitum. Birds were weighed on day 35, 40 and 49. On day 49, one randomly selected bird from each cage was sacrificed and dissected to determine the carcass parameters such as the weight of the cloacal fat, liver, gizzard, pancreas. The price of a kilo of commercial broiler finisher, soy bean meal and maize were 60, 61and 32. Data were analyzed as completely randomize design experiment with five replicates per treatment. Pen means served as replicates in growth and feed intake data analysis while individual bird served as replicates in carcass parameter analysis.

**Results and Discussion**

Effects of the feeding of SM mixtures from 35-40 days on growth performance are shown in Table 2.

The period from 35-40 d is denoted as restricted feeding period (RF) while that from 41-49 is denoted as the *ad libitum* feeding period. During the RF period, birds in dietary regimen 2, 3 and 4 received CF only for three alternate days. By offering SM mixtures in alternate days, theoretically the time available for CF intake was reduced by 50% and thus a similar level of CF intake reduction in MS mixtures fed birds was expected.

Table 1. Nutrient composition of the CF (as given by the manufacturer)

| Nutrients | Composition (%) | |
|---|---|---|
| | Starter | Finisher |
| Protein (Min) | 22 | 20 |
| Fat (Min) | 6 | 7.5 |
| Ash (Max) | 6.5 | 6.5 |
| Fibre (Max) | 4.5 | 4.5 |
| Moisture (Max) | 12 | 12 |
| Calcium (Min) | 1.0 | 0.9 |
| Available phosphorus (Min) | 0.45 | 0.4 |
| Metabolizable energy (Min) | 2950 kcal/kg | 3050 kcal/kg |

However, CF intake reduction during RF period of MS11, MS12 and MS21 groups were 39.7, 39.7 and 41%, respectively. When CF was offered, following a day of SM mixtures feeding, those birds ate more CF than those who received CF uninterruptedly (Fig 1). The CF intakes of the birds given SM mixtures during the three days of which offered were tend to be ($p=0.07$) higher than the CF intake of the birds in dietary regimen 1 during the same three days. It seems that when offered CF following a day of MS mixture feeding, birds have tried to compensate the nutrients what they lost due to the feeding of SM mixtures previous day. Previously we have (Atapattu and Lal;unpublished data) found that when a normal CF was offered after a 6 or 8 hours of feed restriction, birds consumed significantly higher amount of CF during next three hour period, than the in take of CF during the same time period by the birds who were given CF uninterruptedly. Results of this experiment suggest that birds have a kind of 'nutritional wisdom' and try to maintain their nutrient intake after a qualitative feed restriction, by increasing the high quality feed intake, when offered.

Table 2. Performance of broilers subjected to a qualitative feed restriction strategy

| | Dietary Regimen CF | CF/SM11 | CF/SM12 | CF/SM21 | ANOVA |
|---|---|---|---|---|---|
| Feed intake | | | | | |
| RF period (g) | | | | | |
| [1]All com feed days | 549±15 | 619±18 | 605±16 | 605±14 | 0.07 |
| [2]CF and SM mix days | 479±5[a] | 259±15[c] | 312±17[b] | 302±20[cb] | 0.001 |
| Total CF | 1028±17[a] | 619±18[b] | 605±16[b] | 605±14[b] | 0.0001 |
| Total intake (CF+MS) | 1028±22[a] | 878±25[b] | 918±24[b] | 908±9[b] | 0.001 |
| [3]during ad libitum feeding period | | | | | |
| | 1634±31 | 1756±29 | 1773±48 | 1757±57 | NS |
| Total CF intake | 2662±120[a] | 2375±73[b] | 2379±59[b] | 2363±62[b] | 0.03 |
| Total intake (CF+MS) | 2662±120 | 2634±45 | 2691±52 | 2665±57 | NS |
| Live weight (g) | | | | | |
| On day 35 | 1630±5 | 1630±5 | 1621±3 | 1625±4 | NS |
| On day 40 | 2044±22[a] | 1915±11[b] | 1953±17[b] | 1915±26 | [b] |
| 0.001 | | | | | |
| On day 49 | 2584±96 | 2682±31 | 2629±39 | 2633±44 | NS |
| Weight gain | | | | | |
| 35-40d | 414±22[a] | 285±10[b] | 332±19[b] | 290±24[b] | 0.001 |
| 41-49 | 540±85[b] | 767±27[a] | 675±25[ba] | 718±40[ba] | 0.03 |
| 35-49 | 953±98 | 1052±26 | 1008±40 | 1008±33 | NS |
| FCR | | | | | |
| 35-40d | 2.5±0.1 | 3.10±0.1 | 2.8±0.15 | 3.20±0.33 | 0.08 |
| 40-49 | 3.02±0.59 | 2.280±0.09 | 2.62±0.18 | 2.44±0.19 | NS |
| 35-49 | 2.79±0.16 | 2.50±0.06 | 2.66±0.16 | 2.64±0.13 | NS |

1. CF for all groups
2. CF for the first group and respective SM mixtures for the other groups
3. All groups receive CF *ad libitum*

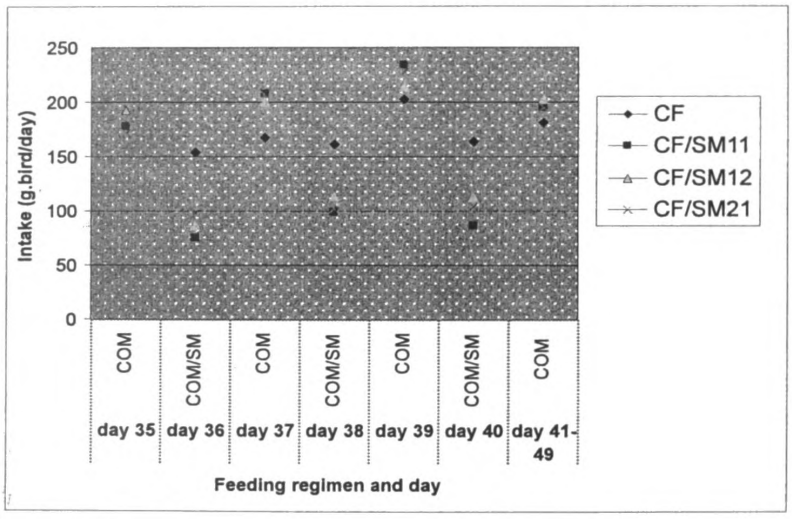


Figure 1. Feed intake pattern of the broiler chicken subjected to qualitative feed restriction

Despite the level of CF intake reduction during RF period was lower than expected, compared to control group, MS mixtures fed birds reported significantly lower CF intake during RF period. During the subsequent *ad libitum* feeding period during which all birds were offered CF, the intake was not significantly different among the four feeding regimens. These findings are in agreement with those of Acar et al.

(1995). However, the total CF intake from day 35-49 was significantly ($P<0.05$) reduced when MS mixtures were offered in alternate days from day 35-40. Six hours (Atapattu and Hemantha (2007) but not three hours (Atapattu and Lal, unpublished data) a day feed withdrawal period reduced the feed intake of broilers. Long feed restriction periods severely reduce the live weight at the end of the restricted feeding period. Consequently, many studies (Ballay et al., 1992; Yu et al., 1990; Boa-Amponsem 1991; Su et al., 1999; Yu et al., 1990; Kuhn et al., 1996; Buys et al., 1998) failed to equate the final live weight of the birds in restricted feeding regimes, compared to control birds. Since feeding is one of the major behavioural activities of broiler chicken, quantitative feed restrictions may have adverse welfare implications. As discussed later, even though the live weight at the end of RF period was reduced in MS mixtures fed birds, the final live weights of those birds were not significantly different from that of control groups. Therefore, results of this experiment suggest that as far as growth performance and animal welfare aspects are concerned, the qualitative feed restriction used in this experiment is better than quantitative feed restriction methods such as feed withdrawal.

In general, all of the SM mixtures were found to be less palatable than CF. Of the three SM mixtures, the intake of SM12 mixture was the most palatable mixture while SM11 was the least palatable mixture. In a similar experiment, Atapattu and Lal (2008) also reported that a maize soy 1:1 mixture was less palatable than commercial feed. Since the CF was nutritionally balanced and in pelleted form higher intake was expected for CF than for MS mixtures. The calculated crude protein and metabolizable energy contents of the CF, MS mixtures and NRC (1994) recommended levels are given in the Table 3.

It is interesting to note that the calculated CP and energy contents of MS12 mixture were close to the NRC recommendations for the respective nutrients.

As expected, birds in RF regimen reported significantly lower weight gains during RF period and, consequently significantly lower in live weight at the end of the RF period. Energy levels of the all MS mixtures were lower than NRC (1994) recommended level and that of the CF used. However, the CP and lysine and methionine contents of the MS mixtures were higher than the recommended levels. Though the *in vitro* nutritive protein values of MS mixtures were at least comparable with those of CF used, birds in RF regimens were showed lower growth rate during RF period. Low MS mixture intakes and the lower nutrient digestibilities of those mixtures compared to the CF maybe the reasons for the reduced growth of the birds in restricted feeding regimens.

Interestingly, when birds were offered commercial feed *ad libitum* from day 41-49, after a period of qualitative feed restriction from 35-40, birds who previously subjected to feed restriction gained more weight than those fed CF uninterruptedly. Also, the birds in feeding regimen 2 (SM11) gained significantly more weight than those in feeding regimen 1. Furthermore, the final live weights of the birds in all four groups were not significantly different from each other. Several authors (Lee and Leeson, 2001; Acar et al., 1995) also reported that birds subjected to feed restriction during early period showed superior performance and FCR during later stages. Meanwhile some authors ((Proudfoot et al., 1983; Summer et al., 1990; Su et al., 1999; Boa-Amponsen et al., 1991; Palo et al., 1991; 1995; Pinchasov and Jensen, 1989; cabel and Waldroup, 1990; Fontana et al., 1992) have reported a reduction in live weight at the end of the feed restriction period and at the end of the subsequent *ad libitum* feeding period. As to whether the compensatory growth capacity is sufficient enough to equate the final body weight depends on many factors such as the type, severity of feed restriction, length and the, timing of the feed restriction and subsequent *ad libitum* feeding.

Table 3. Comparison of the CP and energy contents of feeds used and NRC recommendations

| | Type of feed | | | | |
|---|---|---|---|---|---|
| | CP | SM11 | SM12 | SM21 | NRC (1994) |
| CP (%) | 20 | 26 | 20.3 | 32 | 20 |
| ME (Kcal/Kg) | 3050 | 2790 | 2976 | 2603 | 3200 |
| Lysine | | 2.8 | 2 | 3.7 | 1 |
| Methionine | | 0.5 | 0.39 | 0.6 | 0.38 |

The great differences between the experimental conditions may be a one reason for these discrepancies. The present experiment is different from many of those reported in literature due to two reasons.

Firstly, it employed a qualitative feed restriction. Secondly, this experiment was conducted with relatively mature birds. Balog et al. (2000) failed to show a compensatory growth in mature broiler chicken subjected to quantitative feed restrictions. Meanwhile, we (Atapattu and Belpagodagamage, 2008) found that broiler chicks subjected to qualitative feed restriction from day 27-36 showed a compensatory growth from day 37-42. Results of this experiment confirm that relatively mature broilers also posses compensatory growth capacity following a qualitative feed restriction.

Though not significant, birds subjected to feed restriction gave better FCR s. Our findings are in agreement with those of other studies such as Washburn and Bondari, (1978) and Plavnic and Hurwitz (1988). Improvements in FCR have mainly been attributed to reduced maintenance energy requirement due to lower body weight (Yu and Robinson, 1992) and grater feed intake relative to the body weight and its associated digestive adaptations (Zubair and Leeson, 1994).

Financial analysis showed some additional advantages of this feeding strategy (Table 4). The feed cost for the whole period was not significantly affected by the feeding regimen used. However, the feed per live weight gain of the birds in fed CF uninterruptedly reduced from Rs 166 to Rs 147 when the second dietary regimen was used.

Though not significant, the cloacal fat content of the birds fed second dietary regimen was low, compared to the control group (Table 5).

It is concluded that mature broiler chicken also show compensatory growth following a qualitative feed restriction and that capacity can be used to reduce the feed cost without growth performance being adversely affected.

Table 4. Effect of a qualitative feed restriction strategy on feed cost of broiler chicken from day 35-49'.

| | Dietary regimen | | | | |
|---|---|---|---|---|---|
| | CF | CF/SM11 | CF/SM12 | CF/SM21 | ANOVA |
| Feed cost (RF period) | | | | | |
| CF | 61.6±1.05$^{a}$ | 37.1±1$^{b}$ | 36.93±0.99 | 36.33±0.86 | 0.001 |
| SM mixtures | 12.0±0$^{b}$ | 3.0±0.7$^{ba}$ | | 15.52±1.0$^{a}$ | 0.03 |
| Total cost | 61.68±1.05$^{a}$ | 49.20±1.38$^{b}$ | 49.34±1.25$^{b}$ | 51.85±0.40$^{b}$ | 0.001 |
| Cost/1 kg gain | 148.9±6.5 | 172.9±6.39 | 148.6±8.6 | 178.7±18.6 | NS |
| Feed cost during ad libitum commercial feeding period | | | | | |
| | 98±6.7 | 105.9±1.7 | 106.4±2.9 | 105.4±3.4 | NS |
| Total feed cost | 159±7.2 | 155±2 | 155±3 | 157±3 | NS |
| Cost/1 kg gain | 181.4±2 | 179.9±5.4 | 157.6±10.8 | 146.8±11 | NS |
| Total feed cost/kg gain | | | | | |
| | 166.84±15 | 147.16±3.9 | 153.04±9.9 | 155.75±11.23 | NS |

'The prices of a kilo of CF, soybean meal and maize meal were 60, 61 and 32 Rs respectively.

Table 5. Effect of a qualitative feed restriction strategy on visceral organ and cloacal fat contents*

| | Dietary regimen | | | | |
|---|---|---|---|---|---|
| | CF | CF/SM11 | CF/SM12 | CF/SM21 | ANOVA |
| Cloacal fat | 2.5±1 | 2.0±0.5 | 2.3±0.6 | 1.8±0.9 | NS |
| Liver | 4.6±0.5 | 3.8±0.4 | 4.1±1.1 | 4.6±0.9 | NS |
| Gizzard | 0.9±0.08 | 1.1±0.1 | 1.1±0.1 | 1.0±0.1 | NS |
| Pancreas | 0.2±0.02 | 0.21±0.04 | 0.22±0.04 | 0.2±0.03 | NS |

* as a percentage of empty carcass weight

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