Effects of Energy Level in Finisher Diets and Slaughter Age of on the Performance and Carcass Yield in Broiler Chickens

ABSTRACT

Male broilers were used to evaluate the effects of different energy levels in finisher diets and age of slaughter on performance, production pattern and carcass yield. Experimental design was a 2x3 factorial arrangement: energy level (ME) in the finisher diet (3,200 and 3,600 kcal ME/kg) and age of slaughter (42, 49 and 56 days), resulting in six treatments with four replicates. The finisher diet was fed only in the last week of the growing period. Characteristics evaluated were feed consumption (FC), body weight gain (WG), feed conversion (FC), energy intake (EI), caloric conversion (CC), efficiency production index, production pattern, and carcass yield. The results showed better WG and CC for broilers fed 3,200 kcal ME/kg finisher diet. Broilers slaughtered at 42 and 49 days of age had better performance and higher annual production than broilers slaughtered at 56 days of age. Carcass yield was influenced by slaughter age and better breast yield was seen at 49 and 56 days than at 42 days of age. It was concluded that 3,200 kcal ME/kg induced the best overall performance. Poultry houses were efficiently used when broilers were slaughtered at 42 days of age. Meat:bone ratio was improved for broilers slaughtered at 49 and 56 days of age.

INTRODUCTION

The growing demand for processed poultry products resulted in increased interest from both industry and researchers towards practices that might result in higher yield in broilers, especially cuts with high economical value, such as breast meat. Thus, performance is decisive on poultry production profitability and should be considered together with carcass characteristics. Performance and carcass yield of broilers are influenced by many factors, such as slaughter age and metabolizable energy level in the diet.

Longo (2000) evaluated the growth pattern of Ross broilers from 1 to 112 days and reported that growth rate (g/day) is maximum at 39 days of age for males, and that daily growth rate decreases after 42 days. Kessler et al. (2000) considered that the decrease in growth rate coincides with a progressive reduction on protein deposition, whereas the rate of fat deposition is still high. Therefore, the availability of nutrients for lipogenesis increases if feed intake is not limited after the period of maximum growth. For each 1,000 g of food that is consumed, birds gain 470, 429 and 392 g of weight in the periods from 35 to 42, 42 to 49 and 49 to 56 days, respectively (Manual da Linhagem Ross, 1997). Hence, feed conversion becomes worse with age, and the best age for slaughter should be defined. A second important consideration when defining the best slaughter age is facility utilization. If younger birds are slaughtered, the number of production cycles increases and facility utilization is better.
As for carcass traits, Brake et al. (1993), Rabello (1996) and Young et al. (2001) reported higher breast yield in older birds. Nevertheless, the first two authors also reported higher fat percentage. According to Perreault & Lesson (1992), abdominal fat increases 885% in broiler carcasses from 28 to 70 days of age. The relative increase in abdominal fat is greater than any other part during the same period of time. Since consumers usually reject carcasses with excess of fat, extra effort is needed to remove fat from the carcasses in the processing plant, which might increase the labor cost of processing.

Metabolizable energy (ME) is one of the nutritional factors that mostly affects diet cost. Besides, it greatly influences performance and carcass yield of birds. Araújo (1998) administered diets containing 3,200, 3,400 and 3,600 kcal ME/kg to birds in the final growth phase (44 to 55 days of age) and reported higher weight gain, feed conversion and caloric conversion in birds fed 3,600 kcal ME/kg diet. Similarly, carcass, breast and leg yields were higher with the highest ME level, without concomitant increase in the deposition of abdominal fat.

Since slaughter age greatly influences the yield of commercial cuts, carcass quality, feed efficiency and facility utilization, and since energy level in the finisher diets is also of great importance, the present work had the objective of evaluating performance, production pattern and carcass yield of broilers fed two different levels of ME in the final production phase and slaughtered at three different ages.

**MATERIAL AND METHODS**

During the initial phase, from 1 to 21 days of age (pre-experimental phase), routine management practices were used. Birds were vaccinated against Marek’s disease and fowl pox at the hatchery and against Newcastle disease in the first week of age. A commercial starter diet was used and food and water were given *ad libitum* throughout the experimental period.

Birds were weighed at 21 days of age, before the experimental period, and distributed based on body weight. Mean body weight was 657 g per parcel. Ross birds (1,128) aged 21 days were distributed in a completely randomized design and a 2x3 factorial arrangement, with two levels of energy in the finisher diet (3,200 and 3,600 kcal ME/kg) and three slaughter ages (42, 49 and 56 days), with a total of six treatments and four repetitions each. Finisher diet was given only in the last week, according to slaughter age. Percentage composition and calculated nutritional levels of diets are shown in Table 1.

**Table 1 – Percentage composition and calculated nutritional levels in the experimental diets.**

| Ingredients                | Percentage composition | Calculated nutritional composition |
|---------------------------|------------------------|-----------------------------------|
|                           | Growth                | Finisher                          | Metabolizable energy (kcal/kg) | Crude protein (%) | Ether extract (%) | Sodium (%) | Calcium (%) | Total phosphorus (%) | Available phosphorus (%) | Methionine (%) | Methionine + cystine (%) | Lysine (%) |
| Corn                      | 59.01                  | 66.56                             | 56.87                          | 20.16            | 18.29            | 0.18       | 0.85        | 0.67                          | 0.44                          | 0.50          | 0.86                        | 1.15       |
| Soybean meal              | 32.43                  | 26.29                             | 28.16                          | 20.16            | 18.29            | 0.18       | 0.85        | 0.67                          | 0.44                          | 0.50          | 0.86                        | 1.15       |
| Bicalcium phosphate       | 1.83                   | 1.85                              | 1.88                           | 0.09             | 0.13             | 0.09       | 0.09        | 0.09                          | 0.09                          | 0.09          | 0.09                        | 0.09       |
| Limestone                 | 0.84                   | 0.88                              | 0.85                           | 0.18             | 0.18             | 0.18       | 0.18        | 0.18                          | 0.18                          | 0.18          | 0.18                        | 0.18       |
| Soybean oil               | 4.96                   | 3.56                              | 11.41                          | 8.14             | 7.07             | 0.85       | 0.85        | 0.85                          | 0.85                          | 0.85          | 0.85                        | 0.85       |
| DL – methionine           | 0.09                   | 0.13                              | 0.14                           | 0.09             | 0.13             | 0.13       | 0.13        | 0.13                          | 0.13                          | 0.13          | 0.13                        | 0.13       |
| L – lysine                | 0.09                   | 0.17                              | 0.13                           | 0.09             | 0.17             | 0.17       | 0.17        | 0.17                          | 0.17                          | 0.17          | 0.17                        | 0.17       |
| Vitamin-mineral supplement1| 0.40                   | 0.20                              | 0.20                           | 0.40             | 0.20             | 0.20       | 0.20        | 0.20                          | 0.20                          | 0.20          | 0.20                        | 0.20       |
| Total                     | 100.00                 | 100.00                             | 100.00                         | 100.00           | 100.00           | 100.00     | 100.00      | 100.00                        | 100.00                        | 100.00         | 100.00                      | 100.00     |

1 - Values per kg: vitamin A 1,875,000 IU, vitamin D₃ 375,000 IU, vitamin E 3,250 mg, vitamin K 270 mg, vitamin B₉ 900 mg, vitamin B₃ 2,500 mcg, niacin 6,270 mg, choline 48,800 mg, calcium pantothenate 1,990 mg, iron 14,000 mg, copper 1,750 mg, manganese 14,500 mg, cobalt 21 mg, iodine 150 mg, zinc 12,500 mg, selenium 43 mg, anticoccidial (salinomycin) 250,000 mg, growth promoter (avilamycin) 2,500 mg, antioxidant (BHT) 1,280 mg.

Birds were slaughtered at different ages and, in order to standardize production per area to a predicted 34 kg bird/m², different bird densities were used since the beginning of the experiment. Therefore, 56, 46 and 39 birds were housed at densities of 14.0, 11.5 and 9.7 birds/m² respectively, for the slaughter ages of 42, 49 and 56 days.

Evaluated variables were feed intake (FI), weight gain (WG), feed conversion (FC=FI/WG), energy intake (EI), caloric conversion (CC=EI/WG), production efficiency index (PEI), total broiler production per parcel (TBP), broiler production/m² (BP), total broiler production of birds per year/m² (TBY) and carcass and part yields. PEI was calculated using the formula: (mean daily weight gain x livability)/(feed conversion x 10). TBP is...
broiler produced (kg) per experimental unity, BP corresponds to TBP divided by 4.0 m², which is the physical area per experimental unity. TBY was calculated considering the different slaughter ages and a period of 14 days between flocks, in which the poultry house was empty. This resulted in 6.5, 5.8 and 5.2 production cycles per year for slaughter ages of 42, 49 and 56 days, respectively. Carcass yield and cut yields from six birds per parcel were evaluated. Birds were selected according to mean body weight within the parcel. After a six-hour fast, they were weighed, slaughtered, plucked and eviscerated. Carcass yield and part yields (breast with bone, breast meat, drumsticks, thighs, wings, back, head+neck, feet, edible viscera (heart+liver+gizzard), abdominal fat) were evaluated. Carcass yield (with feet, head+neck and rear fat), abdominal fat (including the fat surrounding the gizzard) and edible viscera were expressed as a ratio of the body weight measured after six-hour fast, whereas other variables were calculated as ratios of the eviscerated and cooled carcass.

Data were analyzed using the software ESTAT 2.0 (1992) and means were compared by Tukey’s test, at a 5% probability level.

**RESULTS AND DISCUSSION**

### Performance characteristics

Performance data are shown in Tables 2, 3 and 6. Diet ME level had no effect on FC and PEI (Table 2). Nevertheless, FI and WG were significantly reduced and CC was worse in birds fed 3,600 kcal ME/kg diet when compared to birds fed the lowest energy level in the finisher diet. Lesson et al. (1996) carried out a free choice experiment with diets containing different ME levels (3,300 vs 3,300; 3,300 vs 3,100; 3,300 vs 2,900 and 3,300 vs 2,700 kcal/kg) and reported that EI was essentially the same between birds of different sizes. It was concluded that modern broilers still have the ability to control feed intake according to the energy level of the diet. Therefore, FI reduction observed in the present study might have been an attempt of the birds not to exceed EI. On the other hand, lower FI might have been a result of the higher level of oil in the diet containing 3,600 kcal ME/kg (11.41 vs 3.56%), which slowed the rate of food passage and reduced feed intake (Mateos & Sell, 1982). Nevertheless, conflicting results have been reported on the effects of oil addition to broiler diets on the rate of food passage. The low WG of the birds fed 3,600 kcal EM/kg was due to a lower FI, which resulted in a lower

### Table 2 – Feed intake (FI), weight gain (WG), feed conversion (FC), energy intake (EI), caloric conversion (CC) and productivity efficiency index (PEI) of broilers fed two energy levels in the finisher diet and slaughtered at different ages.

| Factor | Evaluated characteristics | PEI |
|--------|---------------------------|-----|
|        | FI (kg) | WG (kg) | FC (kg/kg) | EI (kcal/kg) | CC (kcal) | |
| Finisher ME (kcal/kg) | |
| 3,200  | 4.34 a | 2.14 a | 2.01 | 13.876 | 6.419 b | 359 |
| 3,600  | 4.20 b | 2.07 b | 2.00 | 15.132 | 7.216 a | 348 |
|        |         |         |       |         |         |     |
| Growth phase (days) | |
| 21-42  | 2.96 c | 1.65 c | 1.90 b | 10.063 | 6.443 b | 368 a |
| 21-49  | 4.20 b | 2.16 b | 1.95 b | 14.250 | 6.631 b | 368 a |
| 21-56  | 5.65 a | 2.60 a | 2.17 a | 19.200 | 7.379 a | 323 b |
|        | CV (%) | 2.6 | 2.6 | 2.8 | 2.8 | 6.7 |

1 - For each factor, means followed by different letters in the same column are different by Tukey’s test (p<0.05).

### Table 3 – Feed intake (FI), weight gain (WG), feed conversion (FC), energy intake (EI) and caloric conversion (CC) in the last week in broilers fed two energy levels in the finisher diet and slaughtered at different ages.

| Factors | Evaluated characteristics | |
|--------|---------------------------|---|
|        | FI (kg) | WG (kg) | FC (kg/kg) | EI (kcal) | CC (kcal/kg) |
| ME final phase (kcal/kg) | |
| 3,200  | 1.29 a | 0.50 a | 2.62 | 4.126 | 8.379 b |
| 3,600  | 1.14 b | 0.45 b | 2.54 | 4.085 | 9.163 a |
|        |         |         |       |         |         |     |
| Growth phase (days) | |
| 35-42  | 1.13 b | 0.48 b | 2.36 b | 3.830 | 8.022 b |
| 42-49  | 1.23 a | 0.52 a | 2.34 b | 4.141 | 7.945 b |
| 49-56  | 1.28 a | 0.42 c | 3.05 a | 4.344 a | 10.345 a |
|        | CV (%) | 5.6 | 6.1 | 6.4 | 5.8 | 6.3 |

1 - For each factor, means followed by different letters in the same column are different by Tukey’s test (p<0.05).

### Table 4 – Broiler production/m² (BP), total broiler production per parcel (TBP) and total broiler production per year/m² (TBY) of broilers fed two energy levels in the finisher diet and slaughtered at different ages (values represent means of each treatment).

| Factors | Evaluated characteristics | |
|--------|---------------------------|---|
|        | BP (kg/m²) | TBP (kg) | TBY (kg/m²) |
| ME final phase (kcal/kg) | |
| 3,200  | 30.1 a | 120.4 | 175.2 a |
| 3,600  | 29.3 | 117.6 | 170.9 a |
|        |         |         |         |     |
| Growth phase (days) | |
| 21-42  | 29.1 | 116.6 | 189.5 a |
| 21-49  | 30.0 | 120.3 | 173.6 b |
| 21-56  | 29.9 | 120.0 | 156.0 c |
|        | CV (%) | 5.8 | 5.8 | 5.8 |

1 - For each factor, means followed by different letters in the same column are different by Tukey’s test (p<0.05).
Effects of Energy Level in Finisher Diets and Slaughter Age of on the Performance and Carcass Yield in Broiler Chickens

The effects of energy level in finisher diets and slaughter age on the performance and carcass yield in broiler chickens were studied. The researchers found that the intake of all nutrients, since the ME:nutrient ratio was not constant among the experimental diets. Lesson & Summers (2001) reported that diets containing 35 to 40% of fat with ME levels of up to 5,000 kcal/kg might result in excellent growth of young chicks, since the ratio between energy and protein/aminoacid are kept in optimum levels. These authors stated that excessive energy always occurs if the ME:protein/aminoacid ratio is above the regular requirements for growth, production and maintenance. An unbalance of the ME:nutrient ratio in the experimental diet with the highest ME level might also explain the worse CC, because lacking nutrients would limit energy utilization for WG. The use of diets with up to 3,350 kcal EM/kg and constant ME:nutrient ratio during the growth period resulted in better WG and FC for that ME level (Saleh et al., 1997; Pelicia, 2001).

Slaughter age significantly influenced all characteristics. FI and WG were higher with increasing slaughter age. Nevertheless, higher FC, CC and PEI were observed at slaughter ages of 42 and 49 days when compared to 56 days (Table 2). Such lower performance in older birds was due to a decrease in both growth rate and protein deposition, while fat deposition rate was still high. Thus, if feed intake is not restricted after the maximum growth period, the availability of nutrients for lipogenesis will increase, resulting in worse feed conversion (Kessler et al., 2000).

Feed conversion reported by Manual da Linhagem Ross (1997) are 1.87 (21 to 42 days), 1.99 (21 to 49 days) and 2.10 (21 to 56 days). These values are similar to those found in the present study, although slightly worse FC was seen from 21 to 56 days if compared to the expected FC for this strain.

There was interaction between the factors for EI (Table 2), and the means of each treatment (Table 6) showed that EI increased with slaughter age in both ME levels. On the other hand, EI was higher in the birds fed 3,600 kcal ME/kg when compared to 3,200 kcal ME/kg in each age.

As for treatment effects on FI, WG, FC, EI and CC on the last week of growth (Table 3), ME level in the finisher diet did not influence FC and EI significantly, whereas FI and WG reduced and CC increased in birds fed the finisher diet with 3,600 kcal ME/kg. Such performance pattern in the last week of growth was similar to the pattern seen throughout the experimental period, as discussed before. The results

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**Table 5 – Carcass yield and part yields of broilers fed two energy levels in the finisher diet and slaughtered at different ages.**

| Evaluated characteristics (%) | Factors | ME final phase (kcal/kg) | Slaughter age (days) | CV (%) |
|-------------------------------|---------|--------------------------|----------------------|--------|
|                               |         | 3,200                    | 3,600                |        |
| Carcass yield<sup>2,3</sup>   |         | 80.04                    | 80.01                | 80.14  |
| Edible viscera<sup>4</sup>    |         | 3.80 a                   | 3.64 b               | 3.97 a'|
| Abdominal fat<sup>5</sup>     |         | 2.20                     | 2.29                 | 2.08 b |
| Breast with bone<sup>6</sup>  |         | 27.50                    | 27.19                | 26.47 b|
| Breast meat<sup>7</sup>       |         | 21.89                    | 22.48                | 21.19 b|
| Drumsticks<sup>8</sup>        |         | 13.23                    | 13.24                | 13.15  |
| Thighs<sup>9</sup>            |         | 16.02                    | 15.88                | 15.80 b|
| Wings<sup>9</sup>             |         | 10.04                    | 10.09                | 10.37 a|
| Back<sup>10</sup>             |         | 21.62                    | 21.41                | 21.16  |
| Head+Neck<sup>11</sup>        |         | 8.11                     | 8.16                 | 8.63 a |
| Feet<sup>10</sup>             |         | 5.34                     | 5.45                 | 5.67 a |

1 - For each factor, means followed by different letters in the same row are different by Tukey’s test (p<0.05). 2 - There was significant interaction between the factors and treatment means shown in Table 6. 3 - Eviscerated carcass with head, neck, feet and rear fat, on body weight basis. 4 - Heart, liver and gizzard, on body weight basis. 5 - Abdominal fat including fat surrounding the gizzard, on body weight basis. 6 - Based on the weight of the cooled and eviscerated carcass.

**Table 6 – Energy intake (kcal) and carcass yield (%) of broilers fed two energy levels in the finisher diet and slaughtered at different ages (values expressed as means of each treatment).**

| ME final phase (kcal/kg) | Growth phase (days) | Energy intake (kcal) | Carcass yield (%) |
|-------------------------|---------------------|----------------------|------------------|
|                         | 21 – 42             | 21 – 49              | 21 - 56          |
| 3,200                   | 9,643 Cb<sup>1</sup>| 13,835 Bb            | 18,149 Ab        |
| 3,600                   | 10,483 Ca           | 14,664 Ba            | 20,251 Aa        |
| CV = 2.6%               |                     |                      |                  |
| 3,200                   | 80.8 Aa             | 80.0 Ab              | 79.3 Ba          |
| 3,600                   | 79.5 Ab             | 80.4 Aa              | 80.2 Aa          |
| CV = 0.9%               |                     |                      |                  |

1 - Means followed by different capital letters in the rows and small letters in the columns are different by Tukey’s test (p<0.05).
of the present study are different from those reported by Araújo (1998), since when diets containing 3,200, 3,400 and 3,600 kcal ME/kg diet but without constant ME:nutrient ratio were given from 44 to 55 days of age, similar FI was reported between the birds fed diets with 3,200 and 3,600 kcal ME/kg. It was also reported higher EI and WG, besides better FC and CC in birds fed 3,600 kcal EM/kg. It should be noted, however, that Araújo (1998) used Brucker broilers, whereas this study used Ross birds.

All variables evaluated in the last week of growth were also significantly affected by slaughter age. Birds slaughtered at 42 and 49 days showed better performance as expressed by FC and CC. In practice, it is possible to estimate that from 49 to 56 days (FC = 3.05) each bird must eat 710 g more food to gain 1,000 g of weight when compared to the period from 42 to 49 days of age (FC = 2.34). This should be an actual example of the marked decrease that occurs in feed efficiency with increasing age in broilers. Calculated FC based on the values shown in the Manual da Linhagem Ross (1997) are 2.13 (35 to 42 days), 2.33 (42 to 49 days) and 2.53 (49 to 56 days), and thus FC reported here was similar only from 42 to 49 days (Table 3).

Production Pattern

Characteristics that express production pattern are shown in Table 4. It may be observed that ME level in the finisher diet had no significant effect on BP, TBP and TBY. On the other hand, slaughter age significantly affected TBY, indicating that annual broiler production increased with earlier slaughter age, resulting in better facility utilization. Nevertheless, carcass yield and part yields were also affected by slaughter age (Tables 5 and 6). All such aspects must be considered to decide which is the ideal slaughter age according to the final product to be commercialized. The fact that BP and TBP were not significantly affected by treatments indicated that the number of birds was well adjusted in the beginning of the experimental period, although the initial prediction of 34 kg broiler/m² was not achieved.

Carcass yield

Carcass yield and part yields are shown in Tables 5 and 6. There was a significant interaction between the factors for carcass yield (Table 5). Birds fed 3,200 kcal ME/kg and slaughtered at 56 days of age had lower carcass yield than birds slaughtered at 42 days of age (Table 6). Nevertheless, no differences for carcass yield were seen among different slaughter ages for the 3,600 kcal ME/kg level. Best carcass yield was obtained when birds fed 3,200 kcal ME/kg in the finisher diet were slaughtered at 42 days of age. These results do not corroborate those obtained by Reddy et al. (1990), who reported no influence of age on carcass yield. On the other hand, other authors also showed higher carcass yield with increasing slaughter age (Brake et al., 1993; Nunes, 1994; Rabello, 1996; Manual da Linhagem Ross, 1997; Michelan Filho & Souza, 2001).

Higher yields of edible viscera were obtained in birds fed 3,200 kcal ME/kg diet. Other parts were not significantly affected by the energy levels in the finisher diet (Table 5). These results are different from the results reported by Araújo (1998), who found higher carcass, breast and leg yields, and lower back yield. Also, the author did not find differences in the percentages of liver, heart and gizzard in birds fed 3,600 kcal ME/kg diet when compared to the birds fed 3,200 kcal ME/kg. However, Araújo (1998) also reported no influence in the percentages of abdominal fat, wings, head+neck and feet.

Slaughter age affects many commercial cut yields in broilers. Higher yields of breast with bone and breast meat were observed in birds slaughtered with 56 and 49 days of age, respectively. Such results are indicative of a better meat:bone ratio in heavier birds, corroborating results described by Perreault & Lesson (1992) who observed meat:bone ratios of 1.31 at 35 days and 1.57 at 60 days of age. Breast was also the cut with highest growth rate from 43 to 70 days (Perreault & Lesson, 1992), indicating higher efficiency in breast yield of older birds. Better breast yield with increasing age was reported by many authors (Brake et al., 1993; Rabello, 1996; Young et al., 2001). Similarly, data presented by Nunes (1994), Manual da Linhagem Ross (1997) and Michelan Filho & Souza (2001) evidenced higher breast yield in heavier birds. Abdominal fat was also increased in birds slaughtered at 56 days when compared to the birds slaughtered at 42 days of age, corroborating results by Brake et al. (1993) and Rabello (1996). The amount of abdominal fat in the carcass is currently a concern, since consumers consider undesirable the excess of fat in broiler carcasses. In addition, extra work is needed to remove abdominal fat from the carcasses in the processing plant, which might increase the cost of carcass processing. The yield of edible viscera, wings and head+neck decreased in older birds. Reddy et al. (1990) and Rabello (1996) also reported lower yield of edible viscera with age, whereas Brake et al. (1993) also
reported lower yields of head, neck, liver, heart and gizzard with the increase in age from 28 to 49 days. As for wing yield, Brake et al. (1993) reported no significant age effect, but Young et al. (2001) reported conflicting results of wing yield as a function of age. Back and thigh yields were not significantly affected by slaughter age. Such results are different from data reported by Nunes (1994), Manual da Linhagem Ross (1997) and Michelan Filho & Souza (2001), who proposed that part yields increase with body weight in birds.

CONCLUSIONS

Slaughter at 42 days of age allows better utilization of facilities and higher broiler production per year. The use of very high ME level in finisher diet for a small period of time was not enough to positively influence the yield of prime cuts, but higher yield of prime cuts was obtained when birds were slaughtered at 49 and 56 days of age.

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