Response of broiler chickens to different feeding times in the hot humid tropics

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ABSTRACT

An experiment was conducted to determine the response of 7-day-old broiler chickens to different feeding times in a hot, humid tropical area where the prevalent mean environmental temperature and relative humidity were 32 °C and 65 per cent, respectively. The chicks were randomly divided into three quadruplicate lots of 50 birds each and were fed at various times for 7 weeks. Each treatment group of 200 birds was subjected to one of three feeding regimens, namely 24-h access to feed with the aid of artificial light at night (control), access to feed only at day time (from 06.00 to 18.00 h), and access to feed only at night with the aid of artificial light (from 18.00 to 06.00 h). Birds which had 24-h access to feed consumed significantly more feed compared with those on the other treatments. Body weight gain of birds which had 24-h access to feed was significantly higher at 56 days of age, followed by birds which had access to feed only at night and only at daytime. However, efficiency of feed use was poorest for birds which had 24-h access to feed. Mortality rates were influenced significantly by the feeding regimen. Carcass dressing percentage was greatest for birds which had 24-h access to feed. However, the relative weights of the gizzard, liver, heart, and kidney were unaffected by the feeding regimen. Carcass chemical composition was significantly influenced by the various feeding times.

Original scientific paper. Received 13 Feb 98; revised 23 Mar 2000.

RÉSUMÉ

DONKOH, A. & YIRENKYI, K.: *Réaction des poulets de chair aux différents temps d' alimentation dans les tropiques humides chaudes.* Une expérience s' est déroulée pour déterminer la réaction des poulets de chair ayant l' âge de 7 jours aux différents temps d'alimentation dans une zone tropicale humide chaude où la température moyenne courante de l'environnement et l'humidité relative sont respectivement 32 °C et 65 pour cent. Les poussins étaient divisés au hasard en trois quadruples de tas de 50 volailles par chacune et ils étaient nourris aux temps divers pour 7 semaines. Chaque groupe de traitement de 200 volailles étaient soumis à l' un de trois régimes d' alimentation à savoir, 24-h accès à la ration à l'aide de lumière artificielle pendant la nuit (le contrôle), accès à la ration seulement pendant un temps (de 06.00 - 18.00 h) de la journée et accès à la ration pendant la nuit seulement à l'aide de lumière artificielle (de 18.00 - 06.00 h). Les volailles qui avaient 24-h d' accès à la ration consommaient considérablement plus de ration par comparaison avec celles soumises aux autres traitements. Le gain de poids corporel de volailles qui avaient 24-h d'accès à la ration était considérablement plus élevé à l' âge de 56 jours. Suivi par les volailles qui avaient accès à la ration pendant la nuit seulement et celles qui avaient accès à la ration pendant la journée seulement. Toutefois l'éfficacité d' utilisation de ration était les plus médiocres pour les volailles qui avaient 24-h d'accès à la ration. Le taux de mortalité était influencé considérablement par le régime d' alimentation. Le pourcentage de la préparation de carcasse était les plus élevés pour les volailles qui avaient 24-h d' accès à la ration. Les poids relatives de gésier, foie, cœur et rein étaient cependant, non affectés par le régime d' alimentation. La composition chimique de carcasse était considérablement influencée par les temps divers d' alimentation.

Introduction

Economic conditions in recent years have encouraged the development of intensive methods for poultry keeping in tropical areas.

However, certain factors responsible for poor performance in commercial poultry production are often overlooked by poultry practitioners in hot, tropical areas. Broiler performance is dependent on genotype and environment. Ambient temperature is one of the most important environmental factors influencing broiler production in hot climates, where the capital needed to reduce the heat in poultry houses is unavailable. Modern fast-growing commercial broilers show decreased weight gain and food intake, increased mortality, and poorer performance under heat stress (Charles, Groom & Bray, 1981; Daeton, Reece & Lott, 1984; Howlinder & Rose, 1989; Leenstra & Cahaner, 1991; Eberhart & Washburn, 1993). These result in huge losses.

Several approaches have been suggested to improve production performance of broiler chickens in unfavourably hot conditions. These involve measures such as the provision of cool drinking water, the selection of heat-tolerant commercial strains combined with high productivity (Cahaner, Deeb & Gutman, 1992), management practices and dietary adjustments (Wasburn, Peavey & Renwick, 1980; Leeson, 1987), as well as the alteration of feeding times (Daghir, 1995). Feed withdrawal during the hottest hours of the day had become a common management practice in many broiler-producing areas. One suggested practice when a heat wave is expected is to remove feed at 8.00 am and return it at 8.00 pm (Daghir, 1995). The purpose of manipulating feeding times by providing additional light at night to allow broilers to feed during the cooler part of the day is to reduce heat production during the hotter daylight hours and alleviate the adverse effect on performance. Fisher, MacLeod & Mitchel (1985) suggested that eating later in the day may be beneficial and reduce the amplitude of the diurnal rhythm in heat production.

This study was undertaken in the hot, humid tropics to test the response of feeding broiler chickens at different times to ascertain which gives the best response.

Materials and methods

Location of study

The experimental station is located within the semi-deciduous humid forest zone of Ghana at 06° 43'N and 01° 36'S. This zone is characterized by a bimodal rainfall pattern with an annual rainfall of 1300 mm. The major rainy season (62 % of total precipitation) occurs from March to July and the minor season (21 %) from November to February. Daily temperature during the year ranges from 20° to 35 °C with a mean of 26 °C. The relative humidity varies from 97 per cent during the early mornings in the wet season to as low as 20 per cent during the late afternoons in the dry season. The average photoperiod is 12 h.

Animals and housing

The study involved 600 7-day-old commercial broiler chickens. The experiment was conducted in 12 deep litter pens, each measuring 1.83 m × 3.05 m, giving a floor space of 5.582 m^2. Each pen was used as a brooder during the first 2 weeks of the study, and heat was supplied by means of three 100-watt incandescent bulbs per pen. Brooding temperatures ranged from a minimum of 27 to a maximum of 39 °C. Temperature in the poultry house after the brooding period depended on the temperature of the outside air. The maximum and minimum ambient temperatures recorded during the experimental period were 37 and 23 °C, respectively. Relative humidity recorded daily ranged from a minimum of 60 to a maximum of 75 per cent.

Experimental procedure

The study was conducted under three feeding times with each treatment replicated four times. The experimental treatments were as follows:

Treatment 1 (Control): Birds had free access to feed throughout the 7-week period with the aid of supplementary light during the night.

Treatment 2. Birds had access to feed only during the day (from 06.00 to

18.00 h).

Treatment 3. Birds had access to feed only during the night (from 18.00 to 06.00 h) with the aid of artificial lighting.

At the end of each allotted time period, the feed was physically removed from the pens to prevent access of feed. A starter diet containing 221.0 g crude protein kg^{-1} and a metabolizable energy (ME) of 12.0 MJ kg^{-1} was fed for the first 14 days of the experimental period. During the finishing period (3-8 weeks of age), all birds received a diet that contained 200.0 g crude protein kg^{-1} and 11.93 MJ of ME kg^{-1}. Birds had unrestricted access to water throughout the experimental period.

Parameters measured

Feed intake was computed from weekly feed consumption figures, and the birds were weighed weekly from which mean body weight and weight gain per bird were computed. Feed conversion efficiency (feed consumed per unit weight gained) was also determined on weekly basis for individual replicates of each treatment. The mortality rate, which indicates how many birds died out of a total of 50 birds per replicate, was calculated by dividing the number of birds which died within the 7-day period by 50. This was also calculated for the experimental period.

At the end of the experimental period, four chickens per replicate were randomly selected and starved for about 18 h to empty their crops, but with water available. Birds were weighed before slaughter and manually bled, briefly dipped in boiling water, defeathered manually, and eviscerated carcass weights were determined. Carcass dressing percentage was determined as a percentage of the ratio of the eviscerated weight to the liveweight.

The composition of meat was determined on the whole carcass of two slaughtered birds in each replicate. The muscle of each bird was separated from the bone and ground separately three times in an electric grinder. After thorough mixing, aliquots were used for moisture, protein, and ether extract (fat) analysis. The procedures used were as described for meat and meat products by AOAC (1990).

Statistical analysis

The General Linear Models procedure of SAS! (1987) was used to analyze the data and differences between means were determined by the multiple range test. All statements of significant difference imply a probability of 0.05.

Results and discussion

Table 1 shows the general performance of the experimental population. Total feed intake was significantly (P<0.005) affected by the various feeding regimens. Birds on Treatment 1 (24-h access to feed) consumed most feed (5023.9 g), followed by birds on Treatment 3 (access to feed only at night). Least feed consumed per bird (4105.1 g) was recorded for birds on Treatment 2 (access to feed during daytime only). The highest amount of feed consumed by birds on Treatment

TABLE 1

Effect of Different Feeding Times on the Performance of Broiler Chickens from One to Eight Weeks of Age

Response criteria	Treatment 1	Treatment 2	Treatment 3	SE
Feed intake (g)	5023.9^a	4105.1^b	4241.3^b	362.4
Initial 1-week-old bodyweight (g)	101.1^a	100.6^a	100.0^a	0.5
Final bodyweight (g)	1995.7^a	1699.6^b	1882.4^c	42.4
Weight gain (g)	1894.6^a	1599.0^b	1782.4^c	91.7
Food: gain	2.65^a	2.57^a	2.38^b	0.09
Mortality (no. of deaths/no. housed)	10/200^a	9/200^a	2/200^b	1.78

SE - Standard error of the mean

^{a,b} Means within a row having different superscripts differ significantly (P < 0.05).

1 compared to those on the other treatments might be attributed to their unrestricted access to feed. Even though birds which had access to feed only during the night (Treatment 3), when the ambient temperature was much cooler, consumed higher amounts of feed than birds which had access to feed during the hotter daylight hours only (Treatment 2), the difference was not significant ($P > 0.05$). The daytime ambient temperature averaged 37 °C while that for night was 23 °C. It was, therefore, expected that this would have significant impact on feed intake of birds on Treatments 2 and 3, yet this did not result in any considerable difference.

In contrast, other studies (Dvorak & Bray, 1978; Howlinder & Rose, 1989; Eberhart & Washburn, 1993) indicate that lowering the ambient temperature significantly stimulates feed consumption. Hurwitz *et al.* (1980) suggested that the decline in food intake may be derived from diminishing energy requirements for maintenance as temperature increases up to 27 °C, in correlation with decreased oxygen consumption (Barrot & Pringle, 1946) or heat production (Farrel & Swain, 1977). The intake and metabolism of feed have a thermogenic effect.

At lower temperatures, chicks attempt to eat enough to meet the energy demands for growth and temperature maintenance. At high ambient temperatures, particularly when relative humidity is also high, the heat increment aggravates the problem by adding more heat to an already heat-stressed system. Unless the basal metabolic rate can be reduced, or the birds' tolerance of hyperthermia increased, feed intake must decline to allow the maintenance of homeothermy. The bird, therefore, reacts by lowering its voluntary feed intake, thus decreasing the extra heat to be dissipated to the environment and limiting the loss of thermolysis.

Table 1 presents data relating to initial body weight, weight gain, and feed conversion ratios. The average chick weight after selection at 1 week of age, for birds under Treatments 1, 2 and 3 were 101.1, 100.6 and 100.0 g, respectively. Statistically, they were not different from each other. Differences in body weight gains were, however, statistically significant ($P < 0.05$). All the treatments recorded progressive increments in weight gain. The weight gain per bird for chickens which had 24-h access to feed (Treatment 1) was higher than that for the other remaining treatments, i.e. Treatments 2 and 3. In comparison with birds which had access to feed at daytime only (Treatment 2), the body weight gains for those that had feed only at night (Treatment 3) were markedly higher.

The values for birds under Treatment 1 (24-h access to feed) and which consumed significantly higher amounts of feed compared with other treatments are consistent with the observation that increased feed consumption leads to increased weight gain (Nir *et al.,* 1978; Shapira, Nir & Budowski, 1978; Cahaner, Deeb & Gutman, 1993). The higher body weight gain recorded by birds which had access to feed only at night (average ambient temperature of 23 °C) compared with those which had feed only during the hotter daylight hours (average ambient temperature range of 37 °C) is consistent with the observation that over the growing period, the ambient temperature range of 20 - 25 °C is the more suitable, being the same as that for the mature fowls (Meltzer, Goodman & Fistul, 1982; Meltzer, 1983; Charles, 1986).

Fisher *et al.* (1985) reported that above 28 -29 °C, chickens will commence panting. The onset and control of panting require a rise in body temperature (Richards, 1971), and are mediated by warm- sensitive neurons in the spinal cord (Barnas & Rautenberg, 1985). Respiratory frequency and evaporative water loss are linearly related and do increase with ambient temperature above the panting threshold (Geisthovel & Simon, 1984). These energy-consuming responses in hot environment could reduce retention of metabolizable energy, thus reducing growth rate in birds fed during hotter daylight hours only.

Results for the trial indicate that the various feeding times exerted significant ($P<0.05$)

influence on the efficiency of feed use. The performance of birds which had access to feed at night only (Treatment 3) was encouraging in efficiency of feed use. The birds on this treatment were more efficient in converting feed to gain. For feed conversion efficiency, the performance of birds on Treatment 1 (24-h access to feed) was poorer than birds fed on the other regimens.

The experimental birds remained in apparent good health. Mortality (Table 1) seemed dependent on feeding time. A total of 21 mortality cases was recorded during the experimental period; 10 were from chickens which had 24-h access to feed (Treatment 1), nine from those which had access to feed only at daytime (Treatment 2), and only two in birds which had access to feed only at night (Treatment 3). Apparently, feed withdrawal at daytime (Treatment 3) might have lowered the birds' body temperature and increased their ability to survive heat stress during the hot afternoon periods.

This agrees with evidence in the literature which indicates that short-term feed withdrawal can lower the bird's body temperature and increase its ability to survive acute heat stress. McCormick, Garlich & Edens (1979) reported that fasting of 5-week-old broilers for 24, 48 or 78 h resulted in progressively increased survival time when exposed to heat stress. Smith & Teeter (1987, 1988) also studied the influence of fasting duration on broiler gain and survival, and reported that fasting interval from 3 to 6 h before heat stress initiation and totaling up to 12 h daily during significant heat stress (37 °C) reduce mortality significantly.

Broiler chickens with continuous access to feed registered the highest ($P<0.05$) carcass dressing percentage compared to those on other treatments (Table 2), indicating that the feeding regimen significantly influenced this parameter. The lower carcass dressing percentages recorded for birds which had access to feed only at day time (Treatment 2) and only at night (Treatment 3) mainly reflected the lower weight gains. The results corroborate the observation of Donkoh, Atuahene & Kese (1989) of significantly higher

TABLE 2

Effect of Various Feeding Times on Carcass Parameters of Broiler Chickens (% of Liveweight)

	Treatment			
Response criteria	*1*	*2*	*3*	*SE*
Dressing percentage	68.4^a	65.2^b	67.0^c	1.08
Gizzard weight	3.2^a	3.3^a	3.3^a	0.05
Liver weight	2.6^a	2.7^b	2.9^a	0.12
Heart weight	0.5^a	0.4^a	0.5^a	0.05
Kidney weight	0.6^a	0.5^a	0.5^a	0.05
Carcass composition (%)				
Crude fat	26.46^a	20.01^b	21.96^b	2.11
Moisture	56.96^a	58.65^b	58.45^b	0.75
Crude protein	64.69^a	66.31^b	66.87^b	0.73

SE - Standard error of the mean
[a,b,c] Means within a row having different superscripts differ significantly ($P < 0.05$).

carcass dressing percentage for birds which had continuous access to feed and were illuminated constantly. However, the weights of the gizzard, liver, heart, and kidney in this study were not significantly affected by the various feeding times.

The percentage of body fat for birds with continuous access to feed (Treatment 1) was significantly higher than those for birds on the other treatments (Table 2). Since excess dietary energy is stored as fat in the body, the significantly higher amounts of feed consumed by birds which had continuous access to feed meant more extra energy available for storage as fat. As more fat was deposited, it displaced more moisture and the protein content also decreased, with birds on Treatments 2 and 3 recording significantly higher protein contents. Confirmation of this observation is provided in an earlier study by Nir *et al.* (1978) who reported that when birds are fed in excess of normal metabolic needs, fat deposition results, and a considerable proportion is deposited in the abdominal area. Recent studies have also confirmed that body fat of non-ruminants may be influenced by feeding (Kracht, Nurnberg & Schumann, 1993; Schone, Kirchheim & Lange, 1993; Bee & Wenk, 1994; Nurnberg, Kracht &

Nurnberg, 1994).

It is concluded that despite the comparatively lower amounts of feed consumed, the performance of birds which had access to feed only at night (Treatment 3) was encouraging in feed conversion efficiency. It is thus envisaged that if feeding times could be attuned more accurately, improved efficiency of dietary nutrient use may be attainable. Furthermore, feeding birds only at night may reduce weight gain as compared to birds which had access to feed always. One would, therefore, have to weigh the importance of a more rapid growth against a greater mortality risk under hot, humid tropical conditions.

Acknowledgement

The authors gratefully acknowledge the staff of the Animal Science Department, KNUST, Kumasi, Ghana, for their help. They are also grateful to Ms Emma Beatrice Akyeampong for typing the manuscript.

REFERENCES

Association of Official Analytical Chemists (AOAC) (1990) *Official methods of analysis*, 15th edn. AOAC, Arlington, VA, USA.

Barnas, G. M. & Rautenberg, W. (1985) Cardiorespiratory response in pigeon to thermal stimulation of the spinal cord in the opposite direction to external thermal stimulation. *Physiol. Zool.* **58**, 232-235.

Barott, H. G. & Pringle, E. M. (1946) Energy and gaseous metabolism of the chicken from hatch to maturity as affected by temperature. *J. Nutr.* **31**, 35-50.

Bee, G. & Wenk, C. (1994) Einflu B einer Sojaol-und Rindertalgzulage in der Mastration au das Fettsaurenmuster der Lipide in Korper von wachsenden Schweinen. *J. Anim. Phys. Anim. Nutr.* **71**, 277-288.

Cahaner, A., Deeb, N. & Gutman, M. (1992) Improving broilers growth at high temperature by the naked neck gene. *Proceedings of XIX World's Poultry Congress*, Amsterdam, The Netherlands, **2**, 57-60.

Cahaner, A., Deeb, N. & Gutman, M. (1993) Effects of the plumage-reducing naked neck (Na) gene on the performance of fast-growing broilers at normal and high temperatures. *Poult. Sci.* **72**, 767-775.

Charles, D. R. (1986) Temperature for broilers. *Wld Poult. Sci.* **42**, 249-258.

Charles, D. R., Groom, C. M. & Bray, T. S. (1981) The effects of temperature on broilers: Interactions between temperature and feeding time. *Br. Poult. Sci.* **22**, 475-481.

Daghir, N. J. (1995) Broiler feeding and management in hot climates. In *Poultry production in hot climates* (ed. N. J. Daghir). Oxon, UK, pp. 185-218. CAB International.

Deaton, J. W., Reece, F. N. & Lott, B. D. (1989) Effect of differing temperature cycles on broiler performance. *Poult. Sci.* **63**, 612-615.

Donkoh, A., Atuahene, C. C. & Kese, A. G. (1989) Effect of feeding regime and lighting pattern on the performance of broiler chickens in the hot, humid tropics. *Br. Poult. Sci.* **30**, 403-406.

Dvorak, R. A. & Bray, D. J. (1978) Influence of cellulose and ambient temperature on feed intake and growth of chicks. *Poult. Sci.* **57**, 1352-1354.

Eberhart, D. E. & Washburn, K. W. (1993) Assessing the effects of the naked neck gene on chronic heat stress resistance in two genetic populations. *Poult. Sci.* **72**, 1391-1399.

Farrell, D. S. & Swain, S. (1977) Effects of temperature treatment on the heat production of starving chickens. *Br. Poult. Sci.* **18**, 725-734.

Fisher, C., MacLeod, M. G. & Mitchel, M. A. (1985) Feeding at high temperatures - a theoretical approach. In *Proceedings of the European Symposium on Poultry Nutrition, Israel* (ed. S. Borstein), pp. 85-96.

Geisthovel, E. & Simon, E. (1984) In *Thermal physiology* (ed. J. R. S. Hales). New York, Raven Press.

Howlinder, M. A. R. & Rose, S. P. (1989) Rearing temperature and the meat yield of broilers. *Br. Poult. Sci.* **30**, 61-67.

Hurwitz, S., Weiselberg, M., Eisner, U., Bartov, I., Riesenfeld, G., Sharvit, M., Niv, A. & Bornstein, S. (1980) The energy requirements and performance of growing chickens and turkeys as affected by environmental temperature. *Poult. Sci.* **59**, 2290-2299.

Kracht, W., Nurnberg, K. & Schumann, W. (1993) Futterung von Rapsverarbeitungs-produkten und Rapssaat an Mastschweine und Broiler. *Fat Sci. Technol.* **95**, 562-565.

Leenstra, F. & Cahaner, A. (1991) Genotype by environment interactions using fast-growing, lean or fat broiler chickens, originated from The Netherlands and Israel, raised at normal or low temperature. *Poult. Sci.* **70**, 2028-2039.

Leeson, S. (1987) Nutritional consideration of poultry during hot stress. *Wld Poult. Sci. J.* **42**, 104 - 142.

McCormick, C. C., Garlich, J. D. & Edens, F. W. (1979) Fasting and diet affect the tolerance of young chickens exposed to acute heat stress. *J. Nutr.* **109**, 1089-1097.

Meltzer, A. (1983) The thermoneutral zone and resting metabolic rate for broilers. *Br. Poult. Sci.* **24**, 471-476.

Meltzer, A., Goodman, G. & Fistul, J. (1982) Thermoneutral zone and resting metabolic rate of growing White Leghorn type chicks *(Gallus domesticus). Br. Poult. Sci.* **23**, 383-391.

Nir, L., Nitsan, Z., Dror, Y. & Shapira, N. (1978) Influence of feeding on growth, obesity and interstinal tract in young chicks of light and heavy breeds. *Br. J. Nutr.* **39**, 27-35.

Nurnberg, K., Kracht, W. & Nurnberg, G. (1994) Zum EinfluB der Rapskuchenfutte-rung auf die Schlachtkorper-und Fettqualitat beim Schwein. *Zuchtungskunde* **66**, 230-241.

Richards, S. A. (1971) The significance of changes in the temperature of the skin and body core of the chicken in the regulation of heat loss. *J. Physiol.* (Lond) **216**, 1-10.

Schone, F., Kirchheim, U. & Lange, R. (1993) Rapseinsatz bei Schwein. *Fat Sci. Technol.* **95**, 566-570.

Shapira, N., Nir, I. & Budowski, P. (1978) Effect of glucose or oil supplementation on lipogenic enzymes in overfed chicks. *J. Nutr.* **108**, 490-496.

Smith, M. O. & Teeter, R. G. (1987) Potassium balance of the 5 to 8-week-old broiler exposed to constant heat or cycling high temperature stress and the effects of supplemental potassium chloride on body weight gain and feed efficiency. *Poult. Sci.* **66**, 487-492.

Smith, M. O. & Teeter, R. G. (1988) Practical application of potassium chloride and fasting during naturally occurring summer heat stress. *Poult. Sci.* **67** (Suppl. 1), 36.

Statistical Analysis Systems Institute Inc. (SASI) (1987) *Procedures guide for personal computers.* Version 6 edn. SAS Institute Inc. Cary, NC.

Washburn, K. W., Peavey, R. & Renwick, G. M. (1980) Relationship of strain variation and feed restriction to variation in blood pressure and response to heat stress. *Poult. Sci.* **59**, 2586-2588.