Possible effects of delivering methionine to broilers in drinking water at constant low and high environmental temperatures

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Abstract

An experiment was conducted to study the effects of water-soluble DL-methionine supplied through water and feed on the performance and carcass yield of broilers housed at two constant temperatures from 21 to 42 days of age. Birds were housed in two rooms (240 birds per room) with temperatures set at 21±2 and 30±2°C, respectively. Birds were divided into five groups of equal number within each room and fed five different diets (G1-G5). A low-methionine basal diet without supplemental methionine was fed to group 1 (G1). The basal diet was fortified with 0.025% or 0.050% methionine, either in feed (G2 and G3, respectively), or in a water solution (G4 and G5, respectively). Mortality was not significantly altered by any dietary treatment. Neither feed nor water intake was affected adversely by DL-methionine inclusion in drinking water. Housing at high temperature showed deleterious effect on birds’ weight gain. Additional methionine intake both in feed and water was associated with significantly higher body weight, weight gain and feed conversion ratio, than the basal diet at low and high environmental temperature. Carcass yields, as a percentage of live body weight, were not affected by dietary treatment. The results indicate that, under the experimental conditions, DL-methionine provided in drinking water can be effectively assimilated by broilers, at least from 21 to 42 days of age.

Introduction

High environmental temperatures have a negative effect on the performance of broilers during the finishing period, mainly through decreasing feed intake and growth rate or (Adams et al., 1962; Cowan and Michie, 1978; Cerniglia et al., 1983; Han and Baker, 1993; Cheng et al., 1997, 1999; Gu et al., 2008). A variety of experiments has been conducted to demonstrate the growth depression associated with heat stress, and several possible nutritional solutions have been recommended, but have given conflicting results when applied in practice (Balnave, 2004; Syafwan et al., 2011). One strategy for improving live performance of broilers suffering from heat stress was to limit the access to limiting nutrients. The optimum intake of the first-limiting amino acid will affect the requirements of all other amino acids. Methionine is the first limiting amino acid in the conventional corn-soybean and wheat-soybean diets (Leong and Mc Ginnis, 1952; Lemme et al., 2004; Hoehler et al., 2005; Payne et al., 2006), and synthetic methionine has been used for over six decades as a supplement to these diets. Birds under stressful conditions (hot temperature, rapid temperature changes, crowding, etc.) are often unable to eat but are able to drink (Nort and Bell, 1990) thus they would benefit from the delivering of methionine in the drinking water. The use of methionine in drinking water may allow the producers to supply this nutrient rapidly and efficiently, when birds have a reduced food intake. It has been shown that administering methionine in drinking water rather than feed does not result in adverse effects on water and feed intake and production or mortality of poults (Griggs et al., 1971), broilers (Damron and Goodson-Williams, 1987; Damron and Flunker, 1992) or layers (Cadirci, 2001). Both the DL form (Damron and Goodson-Williams, 1987) and the liquid analogue (Damron and Flunker, 1992) of methionine were found to be suitable for supplementation in water without adverse effects. It has also been demonstrated (Cadirci et al., 2009) that layers fed methionine deficient diet are able to select for water supplemented with methionine in preference to pure water, and the way of methionine delivery either in feed or water shows no difference from the point of view of satisfying requirements for normal egg production in laying hens (Cadirci, 2012).

There is no information regarding the performance of broilers receiving methionine in water under heat stress. Therefore, in the present study methionine was administered in water to broilers from 21 to 42 days of age at two different environmental temperatures. The effects were evaluated and a comparison has been made to the traditional way (feeding) of methionine supplying.

Materials and methods

A total of 480 mixed sex broiler chicks (Ross® 308) were used for the experiment. They were subjected to continuous light from day old to the end of the experiment (42 days of age). Birds were fed a crumbled starter diet (CP=23%, ME=3200 kcal/kg), the nutrient specifications were set to meet or exceed NRC (1994) nutrient requirements. Rearing temperatures were 32°C at 1 day then 2°C at 1 week and 26°C at 2 weeks of age.

The experiment began when the chicks reached 21 days of age. A ll birds were wing tagged and placed into cages in two rooms, 240 birds per room. Birds were weighed and two male and two female birds were placed in each cage (50 × 50 × 50 cm). Weights were adjusted so that there were no significant differences in the weight of cages among the various treatments. Throughout the experiment, five different diets were given at both temperatures. For this, a low-methionine basal diet was prepared. Group 1 received basal diet and tap water and no additional methionine. For groups 2 and 3, basal diet fortified with 0.025% or 0.050% methionine from crystalline DL-methionine and tap water was given (G2 and G3, respectively). Groups 4 and 5 (G4 and G5) received basal diet and a water solution of
0.025 or 0.050% of methionine, respectively. For methionine treated water solution, commercially available water soluble crystalline DL-methionine [dl-2-amino-4(methylthio)butanoic acid] was used (Weast, 1975). Treatments were repeated twelve times with four broilers (two male and two female) per replicate. Room temperatures were set at 21±2 and 30±2°C by controlling two air conditioners (White Westinghouse). Relative humidity (RH) in the rooms was not controlled but it was recorded daily. The mean values were 45±0.77% RH at the high temperature and 50±0.84% RH at the low temperature. The response of broilers at high temperatures differs with different relative humidity: high temperature accompanied by high humidity is more detrimental to broiler growth than high temperature with low humidity (Balnave, 2004). As relative humidity was low at both temperatures, only environmental temperature and the way of delivering methionine were the major factors influencing broiler performance.

Prior to the experiment, maize and soybean meal were analysed for crude protein using standard AOAC procedures (AOAC, 1980). Analysis of amino acids was carried out by using ion-exchange chromatography following the procedure of Llamas and Fontaine (1994). Diet was formulated based upon these values. The ingredients used and the calculated nutrient content of the basal diet formulations used in this study are shown in Table 1. Methionine solutions were batch-mixed weekly in tap water in large (60 L) plastic containers, and provided ad libitum according to the design of the experiment through plastic watering bottles (2000 mL) fitted with nipples at the base. One feed-trough and one water bottle were located at the front of each cage. During the course of the experiment all birds were fed ad libitum and every effort was made to ensure their welfare. Each day, the birds were allocated enough feed (1000 g) to exceed the expected daily food intake for broilers of this age and strain. Daily feed intake and water consumption were measured gravimetrically every 24 h and recorded for each replicate, then total and average FI and water consumption were calculated. The water remaining in the bottles was discarded weekly and replaced with fresh water. Methionine intake per replicate was also calculated from the amounts consumed via the feed and water. Chicks were deprived of food for 8 h and individually weighed just before slaughter. At day 42, all birds were manually slaughtered and plucked then feet, head and the intestinal package were removed manually and the remaining carcass was weighed. All carcasses were chilled at approximately 2°C and the next day they were dissected in order to determine yields of breast meat (without bones and skin), thighs (without skin), drumsticks (without skin) and abdominal fat. Carcass yield data were expressed as a percentage of live body weight. Feed conversion ratio (feed intake/weight gain) was calculated to better evaluate overall bird performance. All results were analysed statistically by analysis of covariance using the GLM procedure of the SAS program (SAS, 2001) with temperature, diets and interaction between them as sources of variation. In addition, initial body weight was used as a covariable, in order to eliminate any effect of the initial body weight on the final performance parameters. Significant differences were tested further using a Tukey’s HSD multiple range test to determine the differences among treatments.

Results and discussion

The results for body weight gain, daily feed intake, water intake, methionine intake and feed conversion ratio of birds consuming methionine given either in feed or water at two environmental temperatures during the 21 days of the experiment are shown in Table 2. With the exception of feed conversion ratio, there was no significant interaction between environmental temperature and the way of methionine delivery. Therefore, primary attention is directed to the main effects of environmental temperature and the way of methionine delivery on body weight gain, daily feed, water, and methionine intake. A significant reduction (P<0.05) of body weight gain and feed intake was observed at 30°C compared to 21°C, whereas water intake significantly increased (P<0.05) at the high environmental temperature. The rate of feed intake reduction was greater than that of the increase of water intake, causing a decrease of mean methionine consumption (P<0.05). It has been shown that decreased rate of growth of broilers occurs when environmental temperature rises (Howlider and Rose, 1987). This negative effect of high temperature on performance may primarily be due to a reduced feed intake (Hurwitz et al., 1980). Geraert et al. (1996) reported a greater reduction in growth than in feed intake resulting in a depressed feed efficiency. In this experiment, however, the negative effect of high environmental temperature resulted in similar rates of reduction in body weight gain and feed intake, thus feed conversion ratio was not significantly different at low and high environmental temperature. Thus it seems that, under the conditions of this study, reduced feed consumption and lower body weight gain associated with high temperature in broilers cannot be overcome by delivering methionine in drinking water.

In general, the addition of methionine (at both concentrations) positively affected the birds’ performance from 21 to 42 days of the experiment regardless of the way of delivery or the environmental temperature, the greatest effects being those caused by the high concentration delivered in water (G5). Body weight gain significantly increased with both concentrations and ways of delivery (P<0.05) in comparison to the basal diet. The increase was the smallest with the low level of methionine (0.025%) added to the feed (G2), a significant difference from the other groups. There was no significant difference amongst the other groups in body weight gain. The addition of

| Table 1. Ingredient and nutrient composition of basal diet. |
|----------------------------------------------------------|
| Ingredient composition, %                               |
| Corn, 7.57% CP                                          57.02 |
| Soybean, 46.36% CP                                      33.83 |
| Maize oil                                               5.82  |
| Limestone                                              1.40  |
| Dicalcium phosphate°                                    1.15  |
| NaCl                                                    0.33  |
| Vit/Min. Premix°                                        0.25  |
| Sand°                                                   0.20  |
| Nutrient composition                                    |
| Crude protein, %                                        20.00 |
| Calciumromium, %                                       0.90  |
| Available phosphorus, %                                 0.35  |
| Sodium, %                                               0.15  |
| Arginine, %                                             1.38  |
| Isoleucine, %                                           0.87  |
| Leucine, %                                              1.75  |
| Lysine, %                                               1.11  |
| Methionine, %                                           0.32  |
| Methionine + cystine, %                                 0.66  |
| Threonine, %                                            0.78  |
| Tryptophan, %                                           0.24  |
| ME, kcal/kg                                            3200  |

ME, metabolisable energy. °The composition of dicalcium phosphate provided the following amounts per kg: Ca 215 g and P 200 g. *composition of vitamins and minerals in the premix provided the following amounts per kg of diet: vitamin A, 15,000 U; vitamin D3, 2500 IU; vitamin E, 40 mg; vitamin K3, 5 mg; vitamin B1, 3 mg; vitamin B2, 7 mg; vitamin B3, 5 mg; vitamin B6, 0.02 mg; pantothenic acid, 10 mg; niacin, 40 mg; folic acid, 1 mg; biotin, 0.07 mg; Mn, 80 mg; Fe, 50 mg; Zn, 40 mg; Cu, 5 mg; I, 1 mg; Co, 0.2 mg; Se, 0.15 mg; choline chloride, 300 mg. ±supplemental methionine at 0.025% and 0.050% supplied by dry DL-methionine with the remainder filled by washed sand. *based on analysis of maize and soybean meal. °based on NRC 1994 values for maize and soybean meal and maize oil.
Methionine feed to broilers via water

DL-methionine in feed or water resulted in increased daily feed and water consumption. The increase was statistically significant in all groups except for the water consumption of the group receiving small amount of methionine in feed (G2). Amongst the groups, the only statistical difference in feed and water consumption occurred between birds receiving 0.025% additional methionine through feed (G2) and those getting 0.050% additional methionine in water (G5). Total daily methionine intake significantly increased with the addition of methionine. In turn, the increase of methionine intake resulted in a higher body weight gain. Methionine consumption significantly varied among the groups because of differing concentrations of supplementation in feed or water. It is notable that the addition of methionine at the highest (0.050%) level in feed (G3) and the lowest (0.025%) level in water (G4) resulted in almost the same methionine consumption (4.948 g/day and 4.937 g/day, respectively) and the same performance. Nevertheless, there is a trend of increasing body weight gain as methionine intake increases, the greatest body weight gain (1643.0 g) being associated with the highest waterborne and total methionine consumption (5.749 g/d). These results indicate that the way of delivering methionine (in feed or water) is indifferent from the point of view of satisfying requirements for the birds’ performance. The results obtained for performance traits during this study are similar to those reported by Damron and Goodson-Williams (1987) and Damron and Flunker (1992).

Significant differences (P<0.05) were found among the effects of dietary treatments on feed conversion ratio (Table 2). Consumed feed per unit of body weight gain significantly decreased with supplemental methionine (P<0.05), whether supplied via water or feed. The effect of 0.025% of methionine in feed was the lowest. The delivery of methionine in water (0.025 and 0.050%) had significantly greater effect on FCR (P<0.05).

Figure 1 shows the interaction of environmental temperature and dietary treatment in relation to feed conversion ratio. Feed conversion ratio significantly improved when the highest (0.050%) level of methionine was supplemented in water with the increase of environmental temperature from 21 to 30°C. In addition, the supplementation of 0.050% methionine via water significantly improved feed efficiency compared to 0.050% additional methionine supplied via feed (P<0.05) at high temperature. This might be the result of the consistent supply of methionine via water to the birds under heat stress, and consequently of the improved feed efficiency. The highest methionine consumption was observed when the additional 0.050% methionine was supplied via water. This result is in agreement with the observation by Balnave and Oliva (1990). They found that improved feed conversions resulted when broilers were housed at hot temperatures and fed higher methionine levels than necessary for maximum weight gain at 21°C. In accordance with the works of Damron and Goodson-Williams (1987) and Damron and Flunker (1992).

Table 2. Initial body weight, body weight gain, daily feed intake, water intake, methionine intake and feed conversion ratio of birds consuming methionine in either feed or water at 21 and 30°C.

|    | 21±2  | 30±2  | SEM | Diet | SEM | T  | G  | TxG |
|----|-------|-------|-----|------|-----|----|----|-----|
| IBW, g | 704.0 | 707.2 | 6.18 | G1   |     |    |    |     |
| BWG, g | 1619.6 | 1494.0 | 9.16 | G2   |     |    |    |     |
| FI, g/day | 136.5 | 126.2 | 0.65 | G3   | 1537.5 | 1616.5 | 1688.1 | 1643.0 | 14.49 | 0.001 | 0.001 | 0.241 |
| WI, g/day | 265.8 | 280.5 | 4.67 | G4   | 267.8 | 289.2 | 274.7 | 284.5 | 3.91 | 0.001 | 0.001 | 0.979 |
| MI, g/day | 4.986 | 4.663 | 0.026 | G5   | 4.499 | 4.948 | 4.937 | 5.749 | 0.0411 | 0.001 | 0.001 | 0.344 |
| FCR, g/day | 1.774 | 1.782 | 0.0077 |   | 1.784 | 1.738 | 1.736 | 1.730 | 0.0123 | 0.481 | 0.001 | 0.023 |
| M, % | 0.416 | 0.833 | - |   | 1.042 | 1.042 | 0 | 0 | 1.042 | - | - | - |

T, temperature; G, diets; G1, basal diet; G2, basal diet + 0.025%-added from feed grade dry DL-methionine in feed; G3, basal diet + 0.050%-added from feed grade dry DL-methionine in feed; G4, basal diet + 0.025%-added from feed grade dry DL-methionine in drinking water; G5, basal diet + 0.050%-added from feed grade dry DL-methionine in drinking water; IBW, initial body weight; BWG, body weight gain; FI, daily feed intake; WI, water intake; MI, methionine intake; FCR, feed conversion ratio; M, methionine. SEM values are pooled standard errors of mean for temperature (n=60 replicate) and dietary (n=24 replicate) treatments. *Means in a row within the same treatment with different superscripts differ significantly (P<0.05).
environmental temperature significantly showed similarity with these findings: high decrease is particularly evident in breast meat, which reduce less absolute carcass weight, and this was not affected. On average 0.625% of the observed, therefore, only the main effects for slaughter at 42 days of age. No significant effects of the dietary treatments on eviscerated parts to increase when the basal diet was fortified with methionine either in feed or water to the drinking water of broilers rather than to their diet does not have adverse effects on the performance and carcass yields of birds. In addition, the present work showed that the interaction between methionine supplementation and temperature might positively affect feed efficiency.

Table 3. Body weight, carcass, major carcass parts yield and abdominal fat of birds consuming methionine in either feed or water at 21 and 30°C.

| 21–42 days of age | T, °C | SEM | Diet | SEM | P |
|-------------------|-------|-----|------|-----|---|
| 21±2              |       |     |      |     |   |
| BW, g             |       |     |      |     |   |
| %°                |       |     |      |     |   |
| Carcass           |       |     |      |     |   |
| g                 |       |     |      |     |   |
| %°                |       |     |      |     |   |
| Drums             |       |     |      |     |   |
| g                 |       |     |      |     |   |
| %°                |       |     |      |     |   |
| Thighs            |       |     |      |     |   |
| g                 |       |     |      |     |   |
| %°                |       |     |      |     |   |
| De-boned breast   |       |     |      |     |   |
| g                 |       |     |      |     |   |
| %°                |       |     |      |     |   |
| Abdominal fat     |       |     |      |     |   |
| g                 |       |     |      |     |   |
| %°                |       |     |      |     |   |

T: temperature; G: diets; G1, basal diet; G2, basal diet + 0.025%-added from feed grade dry DL-methionine in feed; G3, basal diet + 0.050%-added from feed grade dry DL-methionine in drinking water; G4, basal diet + 0.075%-added from feed grade dry DL-methionine in drinking water; BW, body weight. SEM values are pooled standard errors of mean for temperature (n=60 replicate) and dietary (n=24 replicate) treatments. °Means in a row within the same treatment with different superscripts differ significantly (P<0.05).

Conclusions

Giving methionine to the drinking water of birds provides an easy way of methionine adjustment in accordance with needs without re-mixing the feed, thus saving the producer the cost of extra equipment, time and labour required when handling feed. An additional
benefit of this method is the consistent supply of methionine to the birds and, consequently, improved feed efficiency. In addition, this practice would allow a better handling of stressful conditions (heat stress, crowdedness). Our data indicated that, under the conditions of this study, liquid DL-methionine can be effectively provided to growing birds through the drinking water, and that interaction between the ways and dosages of methionine supplementation and ambient temperature might positively affect feed efficiency. Substantial savings in the cost of production may be possible should delivering methionine via drinking water be proven feasible under commercial conditions. Therefore, further investigation is needed to verify the efficacy of delivering methionine in water compared to feed, with more dosage levels, with a particular emphasis on the impact of feed efficiency under the heat stress of broiler chickens between 21 to 42 days of age.

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