Possible effects of delivering methionine to laying hens in drinking water

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Abstract

Two experiments were conducted to study the effects of water-soluble DL-methionine supplied through water on the performance of laying hens. Two diet formulations were used in both experiments. For diet 1, nutrient specifications were set to meet or exceed requirements, whereas diet 2 was essentially diet 1 without supplemental methionine. Birds were divided into four groups of equal number. In experiment I, group 1 received diet 1 and normal water. Group 2, 3 and 4 received diet 2 and methionine treated water (0.050% for group 2; 0.075% for group 3; 0.100% for group 4). In experiment II, group 1 received diet 1 and normal water. Groups 2, 3 and 4 received diet 2 and methionine treated water (0.025% for group 2; 0.050% for group 3; 0.075% for group 4). In both experiments there were significant differences in egg weight and methionine intake between the groups, whereas no significant differences were observed in feed intake, water intake, egg production and feed conversion ratio. In the case of egg mass, significant differences between the treatment groups were found in experiment II but not in experiment I. The results suggest that the source of methionine does not influence its metabolic effect. Thus, it seems that methionine from the water is as good as when supplied wholly from the feed.

Introduction

One of the main aims of nutritional research is to reduce the cost of poultry production and increase profit by increasing the utilisation of feeds and nutrients. Methionine is the first limiting amino acid in the conventional corn-soybean and wheat-soybean diets (Leong and Mc Ginnis, 1952; Harms and Damron, 1969; Fisher and Morris, 1970; Schutte and Van Weerden, 1978; Schutte et al., 1983, 1984, 1994; Waldroup and Hellwig, 1995), and synthetic methionine has been used for over six decades as a supplement to these diets. In addition to its main role as a component of proteins it also acts in various metabolic pathways. There are several factors (e.g. feed energy and protein content, age, genotype, sex and various environmental factors) to take into account when balancing the feed formulation (Emmans and Fisher, 1986), therefore amino acids provided by compound feeds will meet a variable proportion of the requirements of the hens in a flock (Boorman and Burgess, 1986). Moreover, once the compound feed is mixed, both its amino acid content and also the extent to which it will meet the requirements of all the hens in any given flock are fixed. In contrast to this, delivering methionine in the drinking water could offer a number of potential advantages.

Small particles in a mixture settle to the bottom while the larger particles work to the surface. The same is true for mash feeds; dry ingredients separate out, especially if the feed is handled often. As feed is handled a great deal before being consumed it is difficult to maintain a good, even mixture of ingredients. In addition, birds have a preference for larger particles: there is evidence that domestic chicks prefer a particle size of 2 to 3 mm (Bessei, 1973; Perry et al., 1976). Dry DL-Methionine particles are very small (300-600 microns), that is much smaller than most ingredients used in commercial feeds, thus segregation of methionine is a potential problem (Anonymous, 1985). Therefore, the provision of a more consistent supply of methionine to the birds would ensure that they all receive the balance of nutrients they require and, consequently, this would improve feed efficiency.

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 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.

Relatively few attempts have been made to supply amino acids to chickens in drinking water, all of which were performed on broilers or poult s. Griggs et al. (1971) succeeded in administering various nutrients, including amino acids, to poult s through the drinking water and observed early weight gain. What is more, mortality and stress were reported to be even reduced (Anonymous, 1984) as a result of this practice. In a later study, Damron and Goodson-Williams (1987) added 0.65% liquid DL-methionine to drinking water while the birds received a low-methionine diet, and they found no adverse effect: neither reductions of feed or water intake, nor any change in rate of mortality were observed. Also, there were no adverse effects on feed intake, water intake, and liveability when 2-hydroxy-4 (methylthio) butanoic acid was added to drinking water (Damron and Flunker, 1992). According to these publications both the DL form (Damron and Goodson-Williams, 1987) and the liquid analogue are suitable for supplementation in water without adverse effects on water and feed intake, and production or mortality of broilers.

Similarly, when methionine was fed to layers through water it did not seem to have any adverse effect on feed and water intake (Cadirci, 2001). It has also been reported by Cadirci et al. (2009) that layers fed methionine deficient diet were able to select for water supplemented with methionine in favour to pure water. The effect of this practice on egg production, however, has not yet been investigated. In the present study the effects of delivering methionine in drinking water to the laying hen were compared to the traditional way of supplying methionine via feed in accordance with NRC (1994) recommendation. The objective was to determine what could be the minimum level of methionine in drinking water that supports the maximum egg production.
Materials and methods

A total of 240 Isa Brown laying hens were used for the study. The birds were placed singly in cages in the experimental house with capacity of 120 cages. The birds were used in two separate groups, 120 for each experiment. The birds at the beginning of experiment I and II were 54 and 60 weeks of age, respectively. Both experiments lasted for 6 weeks. The birds were taken from a 500-hen commercial laying flock. The house was windowless, artificial light was supplied for 16 h (05:00 to 21:00) by 40 Watt tungsten bulbs. Temperature control system of the house was set to maintain a daily average of 23±2°C by controlling the two air conditioners (White Westinghouse, Cranberry, PA, USA). The cages were 30 cm wide, 43 cm high and 46 cm deep. Plastic water bottles (2000 mL) fitted with nipples at the base (Val Watering System, New Holland, PA, USA) were used to supply water. One feed-trough, and one water bottle were located at the front of each cage.

All birds were fed ad libitum one of the experimental feeds. The two diets were formulated as follows: for diet 1 the nutrient specifications were set to meet or exceed nutrient requirements (NRC, 1994) where the level of methionine in the feed was 3.3 g/kg; diet 2 was essentially diet 1 without supplemental methionine so that the calculated level of methionine in the feed was 2.6 g/kg. The ingredients used and the calculated nutrient content of the two diet formulations used in this study are shown in Table 1. Before starting an experiment, a two-week period was allowed for the birds to adapt to diet 1. Each day, the hens were allocated enough feed (250 g) to exceed the expected daily food intake for hens of this age and strain. The normal daily feed intake would be approximately 120 g/day (as per the hatchery guidelines). According to the design of the experiments, birds received Normal water (i.e. plain tap water) or a water solution of three different concentrations of methionine. For this, commercially available, water soluble crystalline DL-methionine (dl-2-amino-4(methylthio)-butanoic acid) was used (Wiest, 1975). Both experiments consisted of four treatments. In experiment I, group 1 received diet 1 and normal water. Groups 2, 3 and 4 received diet 2 and methionine treated water (0.050% for group 2; 0.075% for group 3; 0.100% for group 4). In experiment II, group 1 received diet 1 and normal water. Groups 2, 3 and 4 received Diet 2 and methionine treated water (0.025% for group 2; 0.050% for group 3; 0.075% for group 4). Methionine concentrations used in Experiment II enabled a control of the validity of results obtained in experiment I as well as to see whether further reduction of methionine would still support maximum production.

Daily feed intake and water consumption were measured gravimetrically every 24 h. The water remaining in the bottles were discarded weekly and replaced with fresh water. Methionine intake was calculated from the amounts consumed via the feed and water.

Egg production and egg weight data were recorded. Egg mass (percent egg production x egg weight) and feed efficiency (daily feed intake / egg mass) were also calculated to better evaluate overall hen performance. Hens were weighed at the beginning and end of each experiment. The birds were allocated to the four treatment groups to avoid any significant differences in average initial body weights among the groups. The replicates were randomly assigned in the experimental

Table 2. Average egg production, egg weight, egg mass, feed intake, water intake, feed conversion and calculated methionine intake during experiment 1.

| Period          | Supplemental methionine | Egg production, g/week | Egg weight, g/week | Egg mass, g/week/day | Feed intake, g/week/day | Water intake, g/week/day | Feed conversion | Methionine intake, g/week/day |
|-----------------|-------------------------|------------------------|--------------------|----------------------|-------------------------|--------------------------|----------------------|-----------------------------|
| 54 to 60 week of age | Group 1 (D1 + NW)        | 85.2±1.45              | 64.6±0.28†         | 55.0±0.17‡          | 105.1±2.23              | 193.1±6.70               | 1.93±0.039          | 3.5±0.07†                    |
| 54 to 60 week of age | Group 2 (D2 + 0.050 MTW) | 87.1±1.45              | 64.0±0.13*         | 55.8±1.02*          | 105.4±2.18              | 195.2±8.82               | 1.91±0.045          | 3.8±0.08*                    |
| 54 to 60 week of age | Group 3 (D2 + 0.075 MTW) | 84.2±1.65              | 65.9±0.18*         | 55.4±1.17*          | 104.3±2.59              | 187.7±5.51               | 1.90±0.038          | 4.2±0.09*                    |
| 54 to 60 week of age | Group 4 (D2 + 0.100 MTW) | 88.8±1.14              | 65.7±0.26*         | 53.8±0.80*          | 104.3±1.99              | 199.1±5.68               | 1.80±0.036          | 4.8±0.09*                    |

D1, diet 1; D2, diet 2; NW, normal drinking water; MTW, methionine-treated water. † Values within a column with no common superscript differ significantly (P<0.05). Data are expressed as mean ± SEM (n=15 replicates).
Results

Experiment #1

Performance data are summarized in Table 2. A dietary methionine level of 3.3 g in diet 1 and normal water (group 1) is compared with diet 2 plus 0.050%, 0.075 and 0.100% methionine supplementation in drinking water (groups 2, 3, and 4). In group 1, methionine intake (3.5 g/hen/day) of hens was adequate to meet National Research Council requirements (NRC, 1994). In contrast to experiment I, the lowest level of methionine supplementation in drinking water (0.025%) caused no significant increase in methionine intake as groups 1 and 2 consumed an almost identical amount of total methionine. However, further increasing water supplementation resulted in significant increases of daily methionine intake. Differences observed in the rate of egg production in association with the level of methionine consumed by birds were not significant among the four groups. Egg weight also showed changes in association with methionine intake levels; the increased intake of methionine resulted in the production of significantly heavier eggs in group 3 and 4. In contrast to the findings in experiment I, hens in these two groups produced significantly greater egg mass than those consuming less methionine. Neither feed nor water intake was significantly different for any of the four treatments. Even the lowest level methionine supplementation in drinking water did not cause higher feed conversion efficiency (feed intake to egg mass). Body weight gains by the end of the experiment did not show any significance in relation to treatment (Table 3). There were no mortalities during the experiment.

Table 3. Average initial body weights and weight gains in experiment 1.

| Period                  | Supplemental methionine | Initial body weight, g | Weight gain, g |
|-------------------------|-------------------------|------------------------|----------------|
| 54 to 60 week of age    | (D1 + NW)               | Group 1                | 2049±45.8      | 16±1.6         |
| 54 to 60 week of age    | (D2 + % 0.050 MTW)      | Group 2                | 2163±67.0      | 13±1.3         |
| 54 to 60 week of age    | (D2 + % 0.075 MTW)      | Group 3                | 2047±45.8      | 15±1.3         |
| 54 to 60 week of age    | (D2 + % 0.100 MTW)      | Group 4                | 2131±51.4      | 19±1.5         |

Table 4. Average egg production, egg weight, egg mass, feed intake, water intake, feed conversion and calculated methionine intake during the experiment 2.

| Period                 | Supplemental methionine | Egg production, % | Egg weight, g | Egg mass, g/hen/day | Feed intake, g/hen/day | Water intake, g/hen/day | Feed conversion, g/hen/day | Methionine intake, g/hen/day |
|------------------------|-------------------------|-------------------|---------------|---------------------|------------------------|--------------------------|---------------------------|-----------------------------|
| 60 to 66 week of age   | Group 1                 | 81.0±0.74         | 66.4±0.26     | 53.8±0.50           | 104.4±2.18             | 194.3±6.7                | 194.3±0.03                | 3.4±0.07                     |
| 60 to 66 week of age   | Group 2                 | 81.5±1.39         | 65.2±0.13     | 53.2±0.94           | 107.5±2.41             | 196.2±7.0                | 2.03±0.044                | 3.4±0.07                     |
| 60 to 66 week of age   | Group 3                 | 83.5±2.07         | 67.8±0.19     | 56.6±1.46           | 106.2±3.56             | 188.4±6.03               | 1.89±0.050                | 3.8±0.11                     |
| 60 to 66 week of age   | Group 4                 | 84.6±1.19         | 67.4±0.19     | 56.9±0.77           | 110.7±2.27             | 198.8±5.65               | 1.95±0.040                | 4.5±0.08                     |

D1, diet 1; D2, diet 2; NW, normal drinking water; MTW, methionine-treated water. Data are expressed as mean ± SEM (n=15 replicate).
Table 5. Average initial body weights and weight gains in experiment 2.

| Period          | Supplemental methionine       | Initial body weight, g | Weight gain, g |
|-----------------|------------------------------|------------------------|----------------|
| 60 to 66 wk of age | Group 1 (D1 + NW)          | 2179±38.7              | 17±1.7         |
| 60 to 66 wk of age | Group 2 (D2 + % 0.025 MTW)  | 2286±58.8              | 15±1.3         |
| 60 to 66 wk of age | Group 3 (D2 + % 0.050 MTW)  | 2155±39.8              | 18±1.4         |
| 60 to 66 wk of age | Group 4 (D2 + % 0.075 MTW)  | 2224±54.1              | 18±2.0         |

D1, diet 1; D2, diet 2; NW, normal drinking water; MTW, methionine-treated water. Data are expressed as mean ± SEM (n=15 replicate).

Discussion

Based on the observations that methionine added to the drinking water of broilers rather than to their feed has no adverse effect on production values obtained with the practical diet, and that this practice does not reduce the birds’ feed and water intake (Damron and Goodson-Williams, 1987; Damron and Flunker, 1992), many producers now routinely supplement methionine to the water for the first 21 days after hatching in order to reduce the number of diet changes. In the case of layers, similar observations were made in the present study in as much we found no evidence of adverse effects on the performance of laying hens when methionine was added to their drinking water, i.e. there was no suppression of feed and water intake in consequence of this way of methionine delivery. It is notable that the control diet (NRC, 1994) and the methionine supplemented water diet to the same methionine consumption (3.4 g/hen/day) produced eggs of the same mass, and resulted the same production in experiment II. Moreover, egg production results of the two experiments were similar to one another, and the way of delivering methionine (in feed or water) seemed indifferent from the point of view of satisfying requirements for maximum egg production. Mortality was not related to dietary treatment and weight gain was statistically the same in all groups. It appears that the requirement for body weight gain parallels very closely the requirement for maximum egg production. Egg production results of both experiments suggest that supplying methionine in water, as opposed to methionine in the feed has no known harmful effect on the animals. Total methionine consumption varied significantly among the groups as a result of differing concentrations of feed methionine and liquid methionine. Increases in methionine intake resulted in increasing egg weight and egg mass. On the basis of the results of experiment I and II, no effect on egg production was achieved above a consumption of 3.5 and 3.4 g/hen/day methionine (via feed or water), respectively. On the other hand, egg weight improved significantly in groups 3 and 4 in both experiments. In experiment I egg mass was not affected, whereas in experiment II, egg mass increased significantly as methionine intake increased from 3.4 g/hen/day (groups 1 and 2) to 3.8 g/hen/day (group 3) and 4.5 g/hen/day (group 4) as a result of the influence of different egg weight and numerical difference in rate of lay. These data indicate that, in agreement with the finding of (Harms et al., 1967), the sulfur amino acid requirement for maximum egg weight is higher than for maximum rate of egg production. According to previous studies and a review by Janssen (1974), the methionine requirement of laying hens for obtaining maximum egg mass is less than for maximum efficiency of feed utilization (Schutte and Van Weeren, 1978; Schutte et al., 1983, 1984, 1994). In experiment II hens with different methionine intake (via water) produced different egg mass. However, egg mass does not seem to be affected by methionine intake levels above 3.8 mg per bird. In the case of feed utilisation, increased efficiency was not observed in association with increasing methionine content in drinking water. Although every effort was made to minimise the wastes of water and feed, it is reality that after this effort still the wastes of water and feed could occur. It has to be noted that the findings throughout the experiments do not take into account the wastes. Methionine intakes were calculated from the amounts of consumed feed and water. Therefore, this evaluation most likely overestimate methionine intakes due to losses of feed and water.

Conclusions

In conclusion, methionine is currently supplemented to most commercial layer diet formulations and fed to flocks to influence egg size, egg weight and composition without adverse effect on functionality, mortality rate and weight gain. This is of particular importance for the ever growing liquid egg industry (Shafer et al., 1996; 1998) due to its economic and production advantages. Delivering methionine in drinking water is a flexible way of methionine supplementation to the hens’ diet and provides an opportunity to manipulate the diet without changing the feed. Increasing methionine level of the layer diet should not require additional labour, equipment, or time, therefore, application to flocks dedicated to liquid egg production requires no investment other than the cost of the methionine. This method also can provide a degree of nutrient security or diet formulation flexibility in a poultry starter feed programme and during the laying period; it would also give the opportunity of the consistent supply of methionine to the birds, and consequently, improved feed efficiency. In addition, this practice would aid a better handling of stressful conditions (heat stres, crowdedness). The results indicate that, under the conditions of this study, liquid DL-methionine can be effectively provided to laying hens through the drinking water.

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