The effect of magnesium on thyroid hormone levels and growth of broilers

W. Rattanatayarom 1, K. Angkanaporn 2, H.G. Classen 3

Zusammenfassung

30 weiße Arbor-Acre Broiler (15 männliche, 15 weibliche) im Alter von ca. 4 Wochen und mit einem Durchschnittsgewicht von 778 ± 74 Gramm (Mittelwert und Standardabweichung) wurden unter kontrollierten Bedingungen gehalten: Hell-Dunkel-Zyklus: 16:8 Stunden; Temperatur: 28°C; Luftfeuchtigkeit: 70%. Die Tiere wurden zufällig auf 3 Gruppen verteilt. Die Kontrollen (G1, n=10), erhielten Standardfutter (66 mmol Mg/kg TG, 19% Protein, 4% Fett) und Leitungswasser (0,29 mmol Mg/L) als Trinkwasser ad libitum. Die Mg-normal group erhielt dasselbe Standardfutter (0,29 mmol Mg/L) in form von Magnesium-L-Aspartat HCl. MAH wurde angereichert mit Magnesium-L-Aspartate HCl. MAH war in der ersten Woche signifikant erhöht (p<0,05) im Vergleich zu G1. Während der 2. und 3. Woche fielen die Konzentrationen ab, waren aber in G2 und G3 weiterhin höher als in G1. Die T4-Spiegel waren höher in G2 und G3 als in G1 (p<0,05), sie stiegen bis zur 2. Woche an und fielen in der 3. Woche in allen Gruppen ab. Die Ergebnisse zeigten, dass Mg-Supplementation einen Anstieg von Triiodthyronin und Thyroxin bei Broilern verursachen kann; die erhöhten Schilddrüsenhormonspiegel könnten ein Faktor sein, der das Wachstum in den mit Mg supplementierten Gruppen verbessert.

Summary

30 white Arbor-Acre broilers (15 males; 15 females) aged 4 weeks and weighing 778 ± 74 g (mean ± SD) were maintained under identical feeding conditions, they were exposed to a light-dark cycle of 16 h light: 8 h dark, temperature of 28°C, humidity of 70%. The broilers were randomly divided into three groups: the control group (G1, n=10) was fed standard feed (Mg content 66 mmol/kg dry weight, measured by analysis. protein 19%, and fat 4%) and tap water (Mg content 0,29 mmol/L measured by analysis) as drinking water ad libitum. The Mg-normal group (G2, n=10) and Mg-high group (G3, n=10) received the same food, but drinking water was enriched with Mg in form of magnesium-L-aspartate hydrochloride (MAH). MAH was added in 2 concentrations, 4 g/L and 8 g/L respectively, yielding approximately 16 and 32 mmol Mg/L. Water was offered ad librum for 3 weeks. Mg was supplemented in drinking water in G2, G3 until the end of the experiment. Blood collection was done 4 times with heparinized syringes from wing vein of unfasted animals at the starting week (W0), at one week (W1), two weeks (W2), and three weeks (W3) after Mg supplementation. Totally 116 heparinized blood samples were immediately centrifuged at 4,500 rpm for 10 minutes, plasma samples were separated and stored at -20°C until measurements. All samples were analyzed for Mg and Ca with atomic absorption spectrophotometer from Shimadzu Model 680 from Japan, triiodothyronine (T3), and thyroxine (T4) were analyzed by enzymum-test 73 and enzymum-test 74 by using the equipment named Easynzym-Test System ES 700 from Boehringer Mannheim. Data were analyzed statistically using SPSS for window version 6.1.3. At week three of the experiment, broilers in G3 had higher weight gain than in G1 and G2. Feed conversion rate was also better in G3 than in G1. Plasma Mg of G3, G2 significantly increased (p<0,05) during week 1 to 3 as compared to G1 on the same week while there was no change in plasma calcium. Hormone T3 was significantly increased and higher (p<0,05) in G3 than G1 at week 1 of the experiment. Plasma T3 level declined during week 2 to week 3 but level of T3 in G2, G3 still were higher than in G1. Plasma T4 was higher in G2 and G3 than in G1 (p<0,05) and the T4 level gradually was increased and was highest at week 2 and decreased at week 3 of the experiment in all groups of broilers.

The results suggest that Mg supplementation can increase the level of T3 and T4 in broilers. This increase thyroid hormone may be one of the factors that improve growth in Mg-treated groups.

Introduction

Magnesium (Mg) is an essential activator of about 300 different enzymes, among others enzyme systems using ATP for substrate. Thus Mg is important in several energy-demanding processes such as cell membrane permeability, neuromuscular excitability, protein, nucleic acid and fat synthesis [3]. Atitch et al. in 1983 [1], Grashorn et al. in 1988 [6] and Rattanatayarom et al. in 1996 [12] found that Mg supplements have a tendency towards increased growth rate of broilers probably by improving feed conver-
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Fig. 1: Flow chart of the experiment. G1 = control, G2 = drinking water yielding 16 mmol Mg/L, and G3 = drinking water yielding 32 mmol Mg/L (Mg as MAH).

Water (ml) and Mg (mmol) consumption

Material and method

30 white Arbor-Acre broilers (15 males; 15 females) aged e.g. 4 weeks weighing between 660 to 930 g were maintained under identical field conditions, they were exposed to a light: dark cycle of 16 h light: 8 h dark, temperature of 28 °C, humidity of 70 %. The broilers were randomly divided into 3 groups: The control group (G1, n = 10) received standard food (Mg content 66 mmol/kg dry weight measured by analysis, protein 19 %, and fat 4 %) and tap water (Mg content 0.29 mmol/l measured by analysis) as drinking water ad libitum. The Mg-normal group (G2, n = 10) and Mg-high group (G3, n = 10) received the same food but drinking water was enriched with Mg in form of magnesium-L-aspartate hydrochloride (MAH). MAH was added...
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Food consumption

Body weight

Fig. 3: Mean daily food consumption (top) and increase of body weight of broilers in different groups (bottom)

Weight gain

Fig. 4: Mean daily weight gain of broilers in different groups. W0: 778 ± 74 g

Tab. 1: Feed conversion rate (g/g) of broilers in each group supplementing with MAH. Overall FCR (W1-W3) means of feed intake during W1 to W3 divided by sum of weight gain during W1 to W3.

<table>
<thead>
<tr>
<th>Group</th>
<th>Week (s) after starting the experiment</th>
<th>Overall FCR (W1-W3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W1</td>
<td>W2</td>
</tr>
<tr>
<td>G1</td>
<td>1.85</td>
<td>2.43</td>
</tr>
<tr>
<td>G2</td>
<td>1.69</td>
<td>2.31</td>
</tr>
<tr>
<td>G3</td>
<td>1.78</td>
<td>2.08</td>
</tr>
</tbody>
</table>

in 2 concentrations, 4 g/L and 8 g/L respectively, yielding approximately 16 and 32 mmol Mg/L. Water was offered ad libitum for 3 weeks. Blood collecting was done 4 times with heparinized syringes from wing-vein of unfasted animals at the starting week (W0), at one week (W1), two weeks (W2), and three weeks (W3) after Mg supplementation (see Fig. 1). Totally 116 heparinized blood samples were immediately centrifuged at 4500 rpm for 10 minutes, then plasma samples of each week (W0, W1, W2, W3) were separated and stored at −20 °C until measurements. All samples were analyzed for Mg and Ca with atomic absorption spectrophotometer, Shimadzu Model 680, T3 and T4 were analyzed by enzymun-test E: T3 and enzymun-test II T4 by using the equipment named Enzymun-Test® System ES 700 from Boehringer Mannheim.

Statistics

Data were analyzed with SPSS for window version 6.1.3. All data were first analyzed for normal distribution, homogeneity of variances and then either subjected to parametric ANOVA plus Scheffe-test, or to non parametric ANOVA (Kruskal-Wallis test) followed by Mann-Whitney U-Wilcoxon Rank Sum test. The level of significance was set at 5 %. Plasma calcium, food and water consumption, weight gain, FCR
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Plasma magnesium (mean+SD)

Electrolyte distribution:
Depending on the Mg content of the drinking water, plasma Mg significantly increased during weeks 1 to 3, as compared to control group in the same week (see Fig. 5). There was no change in plasma calcium (data not shown).

Hormone levels:
Triiodothyronine (T3) in plasma was significantly increased and was higher in G3 than G1 at W1. Then plasma T3 level declined during W2 to W3 but level of T3 in G2, G3 still were higher than G1 (see Fig. 6). Hormone thyroxine (T4) in plasma was higher in G2 and G3 than G1 and the T4 level was increased and highest at W 2 and decreased at W 3 of the experiment in all groups of broilers (see Fig. 7).

Discussion
In 1996 Rattanatayarom and colleagues reported on the effect of Mg-supplemented drinking water on broilers. It was found that increased plasma-Mg levels tend to improve food conversion.

Results
General development: Drinking water enriched with different concentrations of Mg was well tolerated by the broilers. No softening of faeces occurred in animals of groups 2 and 3. All broilers survived in acceptable conditions until the end of the experiment. Water consumption increased during the second week; Mg uptake via drinking water amounted to approximately 7 mmol Mg/day in group 2, and 15 mmol Mg/day in group 3 (see Fig.2). Food consumption increased in G3 during W1 to W3 and body weight increased in all groups (see Fig.3). Mean daily weight gain was highest in G3 (see Fig 4). Food conversion rate, i.e. the amount of food necessary to increase one kilogram body weight gain, was the best in group 3 (2.65) compared to group 2 and 1 (2.85, respectively 3.46), as shown in Tab. 1.
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![Graph: Plasma T4 alterations (% of basal levels) (mean+SD)]

Fig. 7: Mean percental thyroxine changes (% T4) in plasma of broilers. Hormone T4 was increased and highest at W2 and decreased at W3, hormone T4 was higher in Mg-treated group than control group.

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