THE EFFECT OF DIETARY MAGNESIUM LEVEL ON THE EGGSHELL QUALITY IN LAYING TSAIYA DUCK AND LEGHORN HEN

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Summary

The study was undertaken to determine the effect of dietary magnesium on the eggshell quality and other performance in laying Tsaiya ducks and Leghorn hens.

Twenty-five Tsaiya ducks and 25 Leghorn hens were raised in individual cages. The basal diet was mainly consisted of corn starch and isolated soybean protein. At the beginning of the experiments, birds were fed for 10 days with the basal diet supplemented with 500 mg/kg Mg (1070 mg/kg in total by analysis) in order to allow the birds adapting to the new diet. Both Tsaiya ducks and Leghorn hens were then each randomly divided into five groups and each group of five birds were fed with the experimental diets containing 690, 1070, 1690, 2150 or 2380 mg/kg Mg, respectively for 21 days. Experiments were repeated three times of which each was initiated at 25, 31 and 36 weeks of age. Eggs were collected in order to measure eggshell quality, Mg and Ca content of the eggshell. At the end of the experiments, blood samples of all birds were taken from their brachial veins for measuring the concentration of Mg and Ca in the plasma.

Experimental results appeared that the dietary Mg content did not significantly affect egg production, egg weight, eggshell breaking strength and thickness in both Tsaiya ducks and Leghorn hens. In Tsaiya ducks, however, the plasma Mg concentration was affected by the dietary Mg content, but the plasma Mg almost reached a plateau (4.66 mg/dl) as long as the dietary Mg level was over 1070 mg/kg. In Leghorn hens, the plasma Mg level was significantly increased from 1.66 mg/dl to 4.03 mg/dl when the dietary Mg content in the diet had been increased from 690 mg/kg to 2380 mg/kg, suggesting that the plasma Mg concentration seems to be directly influenced by the Mg absorbed in the intestine. In the Tsaiya ducks, however, the dietary Mg level did not significantly affect the eggshell Mg content (from 0.113% to 0.123%). Whereas, there was a negative correlation between the eggshell thickness and eggshell Mg content ($r = -0.50$, $p < 0.01$), revealing that the increase in eggshell Mg content probably associated with the impairment of eggshell quality in Tsaiya ducks. In Leghorn hens, however, there was no significant correlation between eggshell quality and eggshell Mg content, although the Mg content in the eggshell was also increased from 0.279% to 0.427% when the dietary Mg had been elevated from 690 mg/kg to 2380 mg/kg.

(**Key Words**: Magnesium, Eggshell Quality, Duck, Leghorn Hen)

Introduction

It has been found that Mg deficiency was detrimental to egg production (Cox and Sell, 1967; Edwards and Nugara, 1968), egg weight (Hajj and Sell, 1969) and eggshell quality in laying fowl (Stafford and Edwards, 1973; Waddell et al., 1989). Hence practical ingredients in layer diets contain a high level of magnesium, therefore, Mg deficiency in practical farming may not occur.

As it has been well known that magnesium is the second abundant metal in eggshell. Brooks and Hale (1955) observed that stronger eggshells contained higher Mg than those weaker eggshells did, and the same result was found by Klingensmith and Hester (1985). On the contrary, a negative correlation was observed between eggshell quality and Mg content in laying fowl by others (Atteh and Leeson, 1983; Chen and Shen, 1989). Therefore, the correlation between eggshell quality and Mg content is still conflicted.

Tsaiya Duck (*Anas Platyrhynchos* var. *domestica*) and Leghorn hen are two main laying fowl in Taiwan. The information on the effect of Mg content in the diet as related to eggshell quality in Tsaiya duck has not been yet studied. The present experiment was therefore undertaken to determine the effects of dietary Mg on the eggshell quality and other performance including that

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of egg production, Mg and Ca content of eggshell in laying Tsaiya ducks and Leghorn hens.

Materials and Methods

Thirty Brown Tsaiya ducks and 30 Hyline single comb white Leghorn hens used in the experiment were selected on the basis of egg production record. In the beginning of the experiment, the average body weights were 1.31 kg and 1.71 kg for Tsaiya ducks and Leghorn hens, respectively. And the average egg productions were 87.8% and 90.1%, respectively for ducks and hens. The experiment was divided into two stages. At the first 10 days, all birds were given the basal diet supplemented with 500 mg/kg Mg (diet 2 in table 1) in order to make the bird adapt to the new diet. Since practical feed ingredients contain a high level of Mg, the experimental diets used were mainly consisted of corn starch and isolated soybean protein. After 10 days of adaptation to the semipurified diet, 25 birds from each fowl were selected and they were each randomly divided into 5 treatments and given

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS

Ingredient	Diets (%)				
	1	2	3	4	5
Corn starch	58.2				
Isolated soy protein (CP 86%)	21.04				
Dicalcium phosphate	1.6				
Calcium carbonate	8.3				
K_2HPO_4	0.7				
$NaHCO_3$	0.59				
Iodized salt	0.30		As diet 1		
Vitamin premix[1]	0.30				
Mineral premix[2]	0.20				
Choline chloride (50%)	0.26				
DL-Methionine	0.3				
Soybean oil	2.0				
Tryptophan	0.05				
Chromic oxide	0.5				
Cellulose	5.66	5.15	4.64	4.13	3.62
$MgSO_4 \cdot 7H_2O$	0	0.51	1.02	1.53	2.04
Total	100.00	100.00	100.00	100.00	100.00
Calculated value:					
Crude protein (%)	18.6				
ME (kcal/kg)	2820		As diet 1		
Calcium (%)	3.5				
Available phosphorus (%)	0.49				
Magnesium added (mg/kg)	0	500	1000	1500	2000
Analyzed value:					
Dry matter (%)	90.2	89.8	89.8	89.6	89.5
Magnesium (mg/kg)	690	1070	1690	2150	2380

[1] Vitamin premix supplied the followings per kilogram of diet: Vitamin A, 11250 IU; vitamin D_3, 1200 ICU; vitamin E, 37.5 IU; vitamin K_3, 2 mg; thiamin, 2.6 mg; riboflavin, 8 mg; vitamin B_6; 3 mg; Ca-pantothenate, 15 mg; niacin, 60 mg; d-biotin, 0.2 mg; folic acid, 0.65 mg and vitamin B_{12}, 0.013 mg.

[2] Mineral premix provided the followings per kilogram of diet: Cu ($CuSO_4 \cdot 5H_2O$, 25.45% Cu) 10 mg; Fe ($FeSO_4 \cdot 7H_2O$, 20.09% Fe) 100 mg; Mn ($MnSO_4 \cdot H_2O$, 32.49% Mn) 60 mg; Zn (ZnO, 80.35% Zn) 65 mg; and Se ($NaSeO_3$, 45.65% Se) 0.15 mg.

the experimental diets (table 1) supplemented, respectively with 0, 500, 1000, 1500, or 2000 mg/kg Mg (690, 1070, 1690, 2150 or 2380 mg/kg Mg by analysis of the diets) for 21 days. Magnesium added was with the $MgSO_4 \cdot 7H_2O$ and cellulose was used for making up the variable due to Mg addition. The feed and water (Mg concentration less than 3 mg/l) were supplied *ad libitum*. Lighting in the house was maintained at 15 hours from 05:30 to 20:30. The experiment was repeated three times each at 25, 31, and 36 weeks of age. Egg production and feed consumption data were recorded throughout the 21 days of experimental period. Eggs were collected and weighed at 6th, 7th, 13th, 14th, 20th, and 21st days after the treatment and each egg was subjected to measurement of its eggshell breaking strength, thickness and the Mg and Ca content. At the end of the experiments, blood samples of each bird were taken at 6 : 00 PM from the brachial vein (V. Ulnaris) with a heparinized syringe and the blood plasma was collected after centrifugation at 1000 g for 10 minutes. The plasma samples were kept frozen until the assay for the Ca and Mg concentrations.

The eggshell breaking strength was determined by using the Fudoh rheometer (NMR-2000 J, Fudoh Kogyo Co;, Tokyo, Japan) to measure the strength needed to break the shell. After the removal of egg white and egg yolk, the eggshell was cleaned and its thickness was then measured at three places including one at the equator and two at the pole ends, using a Peacock dial pipe gauge. Each eggshell with its membrane, including the tested 3 pieces, was dried at 110℃ for 2 hours and ground to pass through a 20-mesh sieve for analysis of the Mg and Ca content. The dry matter and Mg contents of the diets were determined by the method described in the ASSOCIATION OF OFFICAL ANALYTICAL CHEMISTS (AOAC, 1984). The mineral concentration of all samples were analyzed by using Perkin-Elmer 372 Atomic Absorption Spectrophotometer. The magnesium and Ca concentrations in the plasma were measured by diluting 0.025 ml of plasma to 5.000 ml with 0.1% Lanthanum solution (La_2O_3) and analyzed by an atomic absorption spectrophotometer. The eggshell samples were ashed at a temperature of 750℃ for 2 hours. After the ashed samples had been cooled to the room temperature, they were dissolved in 10 ml 3N HCl and then boiled for 10 minutes to enhance their dissolubility. The solution was then filtered into a 100 ml volumetric flask and the volume was brought up to 100 ml with the distilled water and then diluted again with the distilled water to an optimal La concentration of 0.1% for the measurement of Mg and Ca content of the eggshell with an atomic absorption spectrophotometer.

The data obtained were subjected to analysis of variance, and where a significant difference existed, means were further subjected to Duncan's new multiple range test (Steel and Torrie, 1980) to evaluate the difference among treatments.

Results and Discussion

Laying Performance

Table 2 summarizes the average egg production of birds which were fed with various amounts of magnesium in their diets. Although the egg production of Tsaiya ducks in group 5 was better than that of group 3, the dietary Mg level did

TABLE 2. EFFECTS OF THE DIETARY MAGNESIUM CONTENT ON EGG PRODUCTION AND EGG WEIGHT IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Egg production (%)[1]		Egg weight (g)	
		Duck	Hen	Duck	Hen
1	690	94.6[ab]	89.5[a]	60.5[a]	55.0[a]
2	1070	94.9[ab]	85.7[a]	59.1[a]	57.0[ab]
3	1690	89.5[a]	85.7[a]	61.7[a]	56.1[ab]
4	2150	95.1[ab]	89.5[a]	62.2[a]	58.4[b]
5	2380	97.1[b]	90.5[a]	61.8[a]	56.8[ab]

[1] Egg production was presented for hen-day egg production, recorded through experimental period for three replicates.

[ab] Means on the same column without common superscripts differ significantly ($p < 0.05$).

not affect the egg production of Leghorn hens. It is clear that in the present study each group of birds all appeared with a high ability of egg production. Despite of the suggestion that Mg deficiency is of impairment to the egg production of laying hens (Edwards and Nugara, 1968; Hajj and Sell, 1969; Sell et al., 1967; Stafford and Edwards, 1973), and a 500 mg/kg of dietary Mg requirement was recommended by the NRC (1984). The Mg contained in the diets for the present study were all higher than that recommended by the NRC (1984) and it was found that excessive amount (2380 mg/kg) of Mg in the diet did not result in any disadvantageous effect on the egg production. This result agrees with that of Stafford and Edwards' (1973) experiment. They suggested that, as long as the level of Mg content has reached the minimal requirement, an excessive supplementation of Mg in the diets would result in neither positive nor negative effects to the egg production of laying fowl.

The addition of Mg, from 0 to 2000 mg/kg to the basal diet for Tsaiya ducks, had no significant effect on their egg weight (table 2). However, eggs from ducks of the present experiment usually had an average egg weight between 59.1 to 62.2 g and this was slightly smaller than that of the eggs (68 g in average) from laying ducks of commercial farms. This might be due to that the ducks used in the experiments were young and that they were fed with the semipurified diet. Similarly, the effect of Mg addition on egg weight of Leghorn hens was not significant except that of eggs from the hens of group 4 when comparison was made to the eggs from hens of group 1. This result agrees with that reported by Stilborn et al. (1989) and Atteh and Leeson (1983). According to Stafford and Edwards (1973), there was no differences in the weight of eggs from Leghorn hens when their dietary Mg levels were from 655 to 2176 mg/kg, however, the eggs became smaller as the dietary Mg had been reduced to a level of 118 mg/kg.

Magnesium and Calcium Concentration of the Plasma

The dietary Mg levels significantly affect the plasma Mg concentration in both Tsaiya ducks and Leghorn hens (table 3). In Tsaiya ducks, there was a significant correlation between the plasma Mg concentrations and the dietary Mg content ($r = 0.75$, $p < 0.01$). This was particularly found in the first 500 mg/kg of Mg supplementation (group 2) that did result in a significant elevation in the plasma Mg concentration ($p < 0.05$) of the ducks. However, the concentration of plasma Mg soon reached a plateau as the dietary Mg levels were increased up to 1690 mg/kg or more. These results reflect that (1) the Mg threshold in kidney of duck might be about 4.90 mg/dl based on the Mg concentration in plasma, and whenever the plasma Mg concentration is over this value, the excessive Mg will be rapidily eliminated into urine; (2) the absorption efficiency of Mg might be decreased due to the excessively increased dietary Mg; (3) certain amount of absorbed Mg should have been stored in the bone or other tissues; (4) the blood samples were taken during eggshell formation and during this period, the plasma mineral concentration mush be higher than other periods.

Similar results were also observed in the Leghorn hens. As shown in table 3, the plasma Mg level of Leghorn hens was significantly increased from 1.66 to 3.19 mg/dl as 500 mg/kg

TABLE 3. EFFECT OF DIETARY MAGNESIUM CONTENT ON THE CONCENTRATION OF PLASMA MAGNESIUM IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Plasma magnesium (mg/dl) (MEANS ± S.D.)	
		Duck	Hen
1	690	3.73 ± 0.81^{a}	1.66 ± 0.41^{a}
2	1070	4.66 ± 0.81^{b}	3.19 ± 0.31^{b}
3	1690	4.97 ± 0.82^{b}	3.55 ± 0.32^{c}
4	2150	4.91 ± 1.06^{b}	3.82 ± 0.58^{cd}
5	2380	4.90 ± 0.77^{b}	4.03 ± 0.51^{d}

$^{a-d}$ Means on the same column without common superscripts differ significantly ($p < 0.05$).

of dietary Mg had been supplemented into the basal diet. Moreover, the plasma level was further increased up to 4.03 mg/dl when the dietary Mg had been elevated to 2380 mg/kg (figure 1). This indicates that the plasma Mg concentration is directly responded to the amount of Mg that

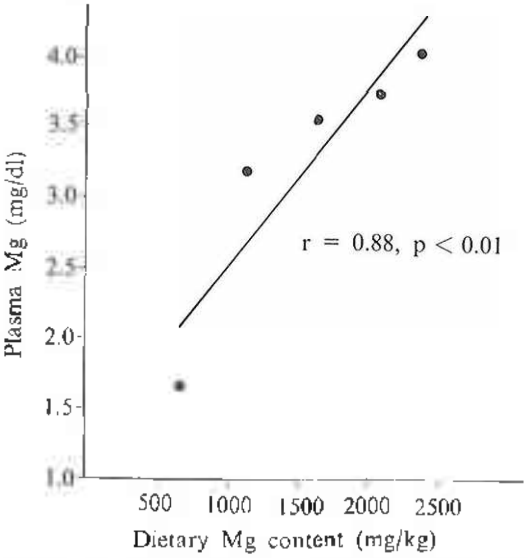

Figure 1. Effect of dietary Mg content on the concentration of plasma Mg in Leghorn hens.

absorbed from the intestine. The effect of supplementing dietary Mg on the elevation of plasma Mg concentration has also been well documented by Cox and Sell (1967), Haj and Sell, (1969) and Sell et al. (1967). Stafford and Edwards (1973) reported that normal concentrations of plasma Mg in the laying hens were located between 2.4 and 4.8 mg/dl. According to this criterion, we found that hens fed basal diet containing 690 mg/kg Mg became hypomagnesia (1.66 mg/dl), while this problem was overcome when the hens had received a higher level of dietary Mg. Welsh et al. (1981) used the broiler chicken for their experiments and proved that the deficiency of Mg inhibited bone reabsorption to this particular mineral and subsequently resulted in decreasing the amount of Mg released from bone. This could be the reason for explaining why chickens soon became hypomagnesia after they had received the diet of Mg deficiency.

The addition of Mg in the diet did not significantly affect the plasma Ca concentration in both Tsaiya ducks and Leghorn hens (table 4). The ranges of plasma Ca concentrations were from 42.34 to 49.29 mg/dl and from 27.05 to 29.36 mg/dl in Tsaiya ducks and Leghorn hens, respectively. These results are similar to that of Stafford and Edwards (1973) who reported that as long as the dietary Mg level reached 118 mg/kg, the plasma Ca of Leghorn hens would be normally ranged between 19.84 to 21.64 mg/dl and there was no more effect followed by further Mg supplementation. The plasma Ca values of both Tsaiya ducks and Leghorn hens in this experiment were also similar to that of Chen and Shen (1989).

Eggshell Quality

The influence of dietary Mg on the eggshell breaking strength is shown in table 5. It is clear that to both Tsaiya ducks and Leghorn hens, the supplementation of dietary Mg within the levels used in this experiment did not subsequently result in any difference in the eggshell breaking strength. The eggshell breaking strength of eggs from Tsaiya ducks and Leghorn hens during the 1st, 2nd and 3rd weeks of treatment period were ranged from 4.58 to 4.97, 4.82 to 5.15, 4.66 to 5.07 kg/cm^2 and 3.72 to 4.00, 3.47 to 3.72, 3.36

TABLE 4. EFFECT OF DIETARY MAGNESIUM CONTENT ON THE CONCENTRATION OF PLASMA CALCIUM IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Plasma calcium (mg/dl) (MEANS ± S.D.)	
		Duck	Hen
1	690	43.52 ± 7.90[a]	27.21 ± 7.45[a]
2	1070	42.40 ± 10.56[a]	28.33 ± 4.22[a]
3	1690	49.29 ± 10.83[a]	29.36 ± 5.53[a]
4	2150	42.34 ± 14.34[a]	27.68 ± 2.93[a]
5	2380	43.89 ± 10.28[a]	27.05 ± 3.53[a]

[a]Means on the same column without common superscripts differ significantly ($p < 0.05$).

TABLE 5. EFFECT OF DIETARY MAGNESIUM CONTENT ON THE EGGSHELL BREAKING STRENGTH IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Eggshell breaking strength (kg/cm^2)					
		Duck			Hen		
		1st wk	2nd wk	3rd wk	1st wk	2nd wk	3rd wk
1	690	4.88[a]	5.03[a]	4.70[a]	4.00[a]	3.72[a]	3.61[a]
2	1070	4.84[a]	4.82[a]	4.77[a]	3.84[a]	3.51[a]	3.64[a]
3	1690	4.97[a]	5.15[a]	5.07[a]	3.84[a]	3.64[a]	3.36[a]
4	2150	4.72[a]	4.96[a]	4.66[a]	3.72[a]	3.59[a]	3.47[a]
5	2380	4.58[a]	4.90[a]	4.84[a]	3.82[a]	3.47[a]	3.53[a]

[a] Means on the same column without common superscripts differ significantly ($p < 0.05$).

to 3.64 kg/cm^2, respectively.

The effect of dietary Mg on the eggshell thickness is shown in table 6. The eggshell thickness of eggs from Tsaiya ducks during the 1st, the 2nd and the 3rd week of the experiment were each ranged from 0.398 to 0.408 mm, 0.399 to 0.412 mm and 0.395 to 0.408 mm, and those values in the Leghorn hens were from 0.374 to 0.384 mm, 0.364 to 0.374 mm and 0.365 to 0.371 mm, respectively. Clearly the supplementation of dietary Mg did not result in a significant increase of the eggshell thickness in both Tsaiya ducks and Leghorn hens. According to Stafford and Edwards (1973), a deficiency of Mg in the diet would result in impairement of eggshell quality and a level of 486 mg/kg Mg in the diet was believed to meet the minimal requirement for Leghorn hens although no more benefit could be obtained by further addition of Mg. Stilborn et al. (1989) also suggested that the addition of 2500 mg/kg Mg in the practical diet for layer did not result in any improvement on their eggshell quality. Cox and Sell (1967) reported that Mg deficiency reduced eggshell weight which associated with the poor quality of eggshell. Sus (1975) found that addition of 500 mg/kg Mg to the diet for laying hens was sufficient to improve the thickness and subsequently reduce the proportion of egg breakage. Similar effect was also confirmed by Lopez (1984) who found that the eggshell strength could be improved due to a certain level of Mg supplementation in the diet. However, according to Benabdejelil and Jenson (1989), no improvement of eggshell quality could be obtained due to the extra amount of Mg addition and excessive amount of Mg supplementation was found rather detrimental to the quality of eggshell (Monsey and Robinson, 1977).

Magnesium and Calcium Content in the Eggshell

Data shown in table 7 reveal that the response of dietary Mg levels on the Mg content in the eggshell was different between Tsaiya ducks and Leghorn hens. The eggshell Mg content from eggs of Tsaiya ducks was rather constantly maintained at 0.114-0.123% no matter what level of Mg had

TABLE 6. EFFECT OF DIETARY MAGNESIUM CONTENT ON EGGSHELL THICKNESS IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Eggshell thickness (mm)[1]					
		Duck			Hen		
		1st wk	2nd wk	3rd wk	1st wk	2nd wk	3rd wk
1	690	.407[a]	.405[a]	.396[a]	.384[a]	.368[a]	.370[a]
2	1070	.398[a]	.399[a]	.395[a]	.381[a]	.372[a]	.368[a]
3	1690	.406[a]	.400[a]	.406[a]	.376[a]	.364[a]	.365[a]
4	2150	.403[a]	.408[a]	.408[a]	.380[a]	.374[a]	.371[a]
5	2380	.408[a]	.412[a]	.407[a]	.374[a]	.367[a]	.365[a]

[a] Means on the same column without common superscripts differ significantly ($p < 0.05$).

[1] The eggshell thickness did not include eggshell membrane.

been supplemented in the diet. However, there was a negative correlation ($r = -0.50$, $p < 0.01$) between the eggshell thickness and the Mg content of eggshell, revealing that the increase in eggshell Mg content had impaired eggshell quality in Tsaiya ducks. This result agrees with that of Chen and Shen (1989) who also found that there was a negative correlation ($r = -0.41$, $p < 0.05$) between the Mg content of the eggshell and the thickness of eggshell in Tsaiya ducks. On the contrary, the addition of Mg in the diet for Leghorn hens resulted in an increase of their eggshell Mg content from 0.279% to 0.427%, although they could not find any significant correlation between the eggshell quality and the Mg content. Chen and Shen (1989) found that the eggshell Mg content was negatively correlated with thickness ($r = -0.84$, $p < 0.05$) in Leghorn hens, so as with Atteh and Leeson (1983). As it was previously observed by Stafford and Edwards (1973) who showed that the Mg content of the shell per se has little or none effect on the shell strength in laying fowl. Nevertheless Brooks and Hale (1955) reported that eggshells with a stronger strength usually contained more Mg than that of the weaker ones did. In the present study, it was found that there was a significantly positive correlation existed between the eggshell Mg content and the Mg concentration in the plasma of Leghorn hens as shown in figure 2 ($r = 0.95$, $p < 0.01$). Therefore, it is possible that the Mg in plasma of Leghorn hens may serve as one of the Mg reservoir for their oviduct requirement or may directly move to the eggshell. On the contrary, in ducks, the plasma Mg concentration may be strictly controlled for the deposition in the eggshell and the plasma Mg content may also act as a Mg reservoir.

TABLE 7. EFFECT OF DIETARY MAGNESIUM LEVEL ON THE MAGNESIUM CONTENT OF EGGSHELL IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Eggshell magnesium (%) (MEANS ± S.D.)	
		Duck	Hen
1	690	0.115 ± 0.010[a]	0.279 ± 0.009[a]
2	1070	0.114 ± 0.011[a]	0.377 ± 0.018[a]
3	1690	0.113 ± 0.011[a]	0.387 + 0.024[a]
4	2150	0.116 ± 0.011[a]	0.394 ± 0.019[a]
5	2380	0.123 ± 0.014[a]	0.427 ± 0.007[a]

[a-c] Means on the same column without common superscripts differ significantly ($p < 0.05$).

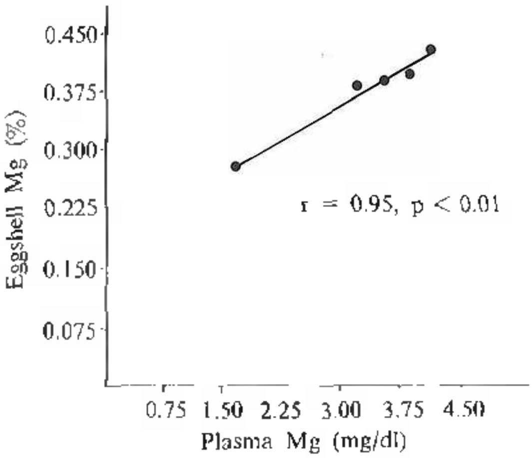

Figure 2. The correlation of plasma Mg concentration and the content of eggshell Mg in Leghorn hens.

Table 8 shows that the amount of calcium contained in the eggshell of both Tsaiya ducks and Leghorn hens was not affected by the levels of dietary Mg. This result is in agreement with that of Holder and Huntley (1978). However, the Ca content of eggshell was decreased when high amount of Mg (1700 to 7700 mg/kg) had been added to the diet (Atteh and Leeson, 1983). Futhermore, Stillmak and Sunde (1971) and Lee and Britton (1987) indicated that high dietary Mg induced catharsis to reduce the absorption efficiency of mineral in the intestine.

The different results from different research might be due to the dietary Mg level used in the study. For example, the addition levels of Mg used by Holder and Huntley (1978) was much lower than that of some others did. In the present study, we conclude that the corn starch-isolated soy protein type diets containing more than 690 mg/kg Mg are quite sufficient for both

TABLE 8. EFFECT OF DIETARY MAGNESIUM LEVEL ON CALCIUM CONTENT OF EGGSHELL IN TSAIYA DUCKS AND LEGHORN HENS

Group	Dietary Mg (mg/kg)	Eggshell calcium (%) (MEANS ± S.D.)	
		Duck	Hen
1	690	38.44 ± 0.60[a]	36.50 ± 1.05[a]
2	1070	38.07 ± 1.03[a]	36.25 ± 1.25[a]
3	1690	38.24 ± 0.47[a]	36.05 ± 0.41[a]
4	2150	38.09 ± 0.34[a]	35.27 ± 0.57[a]
5	2380	38.14 ± 0.66[a]	35.82 ± 0.20[a]

[a]Means on the same column without common superscripts differ significantly ($p < 0.05$)

Tsaiya ducks and Leghorn hens to meet their requirements.

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Literature Cited

A.O.A.C. 1984. Official Methods of Analysis. 14th ed. Arlington, VA.

Atteh, J. O. and S. Leeson. 1983. Influence of increasing dietary calcium and magnesium levels on performance, mineral metabolism, and egg mineral content of laying hens. Poultry Sci. 62:1261-1268.

Benabdeljelil, K. and L. S. Jenson. 1989. Effect of distillers, dried grains with solubles and dietary magnesium, vanadium and chromium on hen performance and egg quality. Nutr. Rep. Int. 39:451-459.

Brooks, J. and H. P. Hale. 1955. Strength of the shell of the hen's egg. Nature 175:848-849.

Chen, W. L. and T. F. Shen. 1989. Comparative studies on the utilization of calcium between laying Tsaiya duck and Leghorn hen. Asian-Australasian J. Anim. Sci. 2:67-75.

Cox, A. C. and J. L. Sell. 1967. Magnesium deficiency in the laying hen. Poultry Sci. 46:675-680.

Edwards, H. M., JR. and D. Nugara. 1968. Magnesium requirement of the laying hen. Poultry Sci. 47: 963-966.

Hajj, R. N. and J. L. Sell. 1969. Magnesium requirement of the laying hen for reproduction. J. Nutr. 97:441-448.

Holder, D. P. and D. M. Huntley. 1978. Influence of added Manganese, magnesium, zinc, and calcium level on egg shell quality. Poultry Sci. 57:1629-1634.

Klingensmith, P. M. and P. Y. Hester. 1985. Effects of an induced molt and shell quality on the physical dimensions and mineral composition of eggs and intrauterine pH. Poultry Sci. 64:2368-2376.

Lee, S. R. and W. M. Britton. 1987. Magnesium induced catharsis in chicks. J. Nutr. 117:1907-1912.

Lopez, R. L., A. P. Gonzalez and R. M. Rosiles. 1984. Suplementacion con magnesio en dietas de gallinas de postura y su effecto sobre la calidad interna y externa del huevo. Vet. Mex. 15:31-37.

Monsey, J. B. and D. S. Robinson. 1977. The effect of feeding magnesium-enriched diets on the quality of the albumen of storage eggs. Br. J. Nutr. 37: 35-44.

NRC. 1984. Nutrient requirements of poultry. 8th ed. National Academy of Sciences, Washington, D. C.

Sell, J. L., R. Hall, A. Cox and W. Guenter. 1967. Effect of magnesium deficiency in the hen on egg production and hatchability of eggs. Bri. Poult. Sci. 8:55-63.

Stafford, J. E. H. and N. A. Edwards. 1973. Magnesium metabolism in the laying fowl. Br. Poult. Sci. 14:137-148.

Steel, R. D. G. and J. H. Torrie. 1980. Principles and procedures of statistics. 2nd ed. McGraw-Hill Book Co., Inc. New York, N.Y.

Stilborn, H. L., H. M. Hellwing and P. W. Waldroup. 1989. Effect of supplemental magnesium in diets of laying hens on egg production and egg quality parameters. Nutr. Rep. Int. 40:123-128.

Stillmak, S. J. and M. L. Sunde. 1971. The use of high magnesium limestone in the laying hen. 2. Calcium and magnesium availability. Poultry Sci. 50:564-572.

Sus, H. 1975. Magnesium zusatz bei legehennen. Arch. Gefluglek. 39:99-102.

Waddell, A. L., R. G. Board, V. D. Scott and S. G. Tullett. 1989. Influence of dietary magnesium content on laying performance and egg shell magnesium content in the domestic hen. Bri. Poult. Sci. 30:865-876.

Welsh, J. J., R. Schwartz and L. Krook. 1981. Bone pathology and parathyroid gland activity in hypocalcemic magnesium-deficient chicks. J. Nutr. 111: 514-524.