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Calcium Requirement for Bone Maintenance of Aged Non-Laying Hens[1]

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ABSTRACT Two experiments were conducted utilizing 312 egg production-type hens which had been maintained for ten months of lay in individual cages. A depletion diet of 0.11% calcium was fed to cause the hens to go out of production. After production ceased, diets containing graded levels (0.02, 0.06, 0.10, 0.18 and 0.54%) of calcium were fed. It was found that hens fed 0.54% calcium started to come back into production, but that lower levels down to 0.02% did not adversely affect tibia breaking strength or tibia ash. It was concluded that the non-laying hen's calcium requirement for bone maintenance is 0.02% or less. There was a highly significant correlation between breaking strength and tibia ash, and between body weight and breaking strength.

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INTRODUCTION

EXTENSIVE research has been conducted to determine the calcium requirement of the laying hen. Berg *et al.* (1964) found that the calcium requirement of 8–21 week old pullets, based on growth, bone ash and laying house performance, was not over 0.40% when the calcium:phosphorus ratio was 1:1 to 2:1. Once the pullet comes into production the calcium requirement increases to approximately 2.75% (N.R.C., 1971) and may be even higher during hot weather. Hurwitz and Griminger (1961) found that hens receiving less than three grams of calcium per day went into a negative calcium balance state.

While the calcium requirement of laying hens has been determined, the requirement for a non-laying and/or molting hen has not been established. The calcium requirement for mature White Leghorn males was found to be not more than 0.20% by Wilson *et al.* (1969). Norris *et al.* (1972), using purified diets, reported that the calcium requirement for bone mineral maintenance was 0.0035% for adult males; however, 0.0028% was required for positive calcium balance. The latter value was equivalent to 7.98 mg. calcium per kg. of body weight daily. It is assumed that a non-laying hen which had been in production would have a calcium requirement higher than that of a male due to a loss of bone salts which would have to be replaced. Rowland and Harms (1972) found that there was a significant decrease in tibia ash within four weeks after the onset of egg production and this reduction in tibia ash was maintained during the lay period. Breaking strength of bones of hens in cages was reduced after eight weeks of lay. Rowland *et al.* (1968) found that increasing the dietary calcium for three weeks increased bone strength of old caged layers. The purpose of the following experiments was to determine the hen's requirement for calcium for bone maintenance when in a non-laying state.

EXPERIMENTAL PROCEDURE

Two experiments were conducted with 312 egg production-type hens which had just ended their tenth month of production. They were maintained in individual 20.3 × 45.7 × 45.7 cm. cages. They had been receiving the control diet (Table 1) for the ten-month laying period. The first

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TABLE 1.—*Composition (ingredient percentages) of diets*

Ingredients	Control	Depletion	Experimental				
Calcium Level	3.0%	0.11%	0.02%	0.06%	0.10%	0.18%	0.54%
Yellow corn	69.90	69.90	95.95	95.95	95.95	95.95	95.95
Soybean meal (50% protein)	19.00	19.00	—	—	—	—	—
Alfalfa meal (20% protein)	2.50	2.50	—	—	—	—	—
Ground limestone	5.90	—	—	—	—	—	—
Defluorinated phosphate	1.95	—	—	—	—	—	—
Iodized salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Micro-ingredients[1]	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sand	—	7.85	2.30	2.20	2.10	1.90	1.00
Reagent $CaCO_3$	—	—	—	0.10	0.20	0.40	1.30
Sodium acid phosphate	—	—	1.00	1.00	1.00	1.00	1.00

[1] Supplied per kg. of feed: vitamin A, 6600 I.U.; vitamin D_3, 2200 I.C.U.; menadione dimethylpyrimidinol bisulfite, 2.2 mg.; riboflavin, 4.4 mg.; pantothenic acid, 13.2 mg.; niacin, 39.6 mg.; choline chloride, 499.4 mg.; vitamin B_{12}, 22 mcg.; ethoxyquin, 0.0125%; manganese, 60 mg.; iron, 50 mg.; copper, 6 mg.; cobalt, 0.198 mg.; iodine, 1.1 mg.; zinc, 35 mg.

experiment was started August 30, 1968, while the second was initiated on January 12, 1972. In both experiments the hens were randomly divided into eight treatment groups, each containing three replications. At this time, all hens except the controls were placed on the depletion diet containing 0.11% calcium (Table 1). They were maintained on this diet for two weeks at which time all had ceased production. The eight experimental diets which were fed for a period of four weeks were as follows: 0.02, 0.06, 0.10, 0.18, 0.54 and 3.0% calcium; the diets containing 0.06 and 0.10% calcium were also fed with 13.2 mg./kg. of progesterone. The progesterone was used to insure that the hens remained out of production. Feed and water were available *ad libitum* and the hens were on 16 hours of light per day.

In experiment 1 individual body weights were taken at the termination of the experiment, and in the second experiment body weights were taken at the beginning and end of the four-week feeding period.

Upon completion of the feeding period all hens were sacrificed and the left tibia was removed and then defleshed after cooking six minutes in boiling water. The tibiae were air dried at room temperature for 48 hours and broken on an Allo-Kramer shear press according to the procedure of Rowland *et al.* (1967). A downspeed of 1 cm./2.5 seconds was used with a distance between the two bone supports of 87 mm. The fragments from each bone were collected and alcohol extracted for 24 hours, ether extracted for 24 hours, redried and then individual tibia ash values were determined according to standard A.O.A.C. procedures (A.O.A.C., 1970).

The data were subjected to the analysis of variance (Snedecor, 1956). The treatment × experiment interaction was significant for feed intake and body weight data; these data are therefore presented by experiment. There were no significant treatment × experiment interactions for breaking strength and tibia ash and these data were combined for the two experiments. Significant differences between treatment means were determined by multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Increasing the dietary calcium level from 0.02 to 0.18% gave numerical increases in breaking strength and tibia ash; these were not, however, statistically sig-

TABLE 2.—*Tibia breaking strength and tibia ash*

% Calcium	Breaking strength* (kg.)	Tibia ash* (%)
0.02	11.63[a]	55.8[a]
0.06	11.86[a]	56.2[a]
0.06+progesterone**	12.24[a]	57.3[a]
0.10	11.89[a]	55.5[a]
0.10+progesterone**	12.44[a]	56.9[a]
0.18	12.77[ab]	57.6[a]
0.54	13.61[b]	59.3[b]
3.00	15.80[c]	59.6[b]

* Means with different superscripts are significantly different according to Duncan's multiple range test ($P<0.05$).
** 6 chloro Δ^6-17-acetoxy progesterone.

nificant (Table 2). When the calcium level of the diet was increased to 0.54% a significant increase was obtained in breaking strength and tibia ash. A greater increase in breaking strength was obtained in experiment 2 when the calcium was increased to 3.0% than was obtained in experiment 1. The difference between experiment 1 and experiment 2 might be attributed to a difference in feed intake; the birds in experiment 2 consumed considerably more feed than those in experiment 1 (Table 3).

It may be concluded from the bone ash and tibia breaking strength data that the non-laying hen does not require more than 0.02% dietary calcium for bone maintenance. This would indicate that the typical practical diet could be used for molting hens without supplemental calcium. When the diets containing 0.06 and 0.10% calcium were suplemented with progesterone a numerical increase in breaking strength was obtained. This was also accompanied by a small increase in bone ash. This small difference in breaking strength and bone ash was partially attributed to the increased feed intake from the addition of progesterone to the diet in experiment 1. This increase in feed intake agrees with a previous report by Wilson *et al.* (1967).

Correlation coefficient on individual hens was found to be + 0.449 for breaking strength and tibia ash. This was significant at the 0.01 level of probability, and agrees with earlier work (Rowland *et al.*, 1967) which indicated that tibia strength was highly correlated to tibia ash for chicks fed graded levels of calcium and phosphorus.

With the exception of an occasional egg all hens remained out of production except those fed 0.54% calcium. The control group continued to lay throughout the experiment at approximately the same rate as before the initiation of the experiment. The 0.54% calcium level appeared

TABLE 3.—*Feed consumption and body weights*

% Calcium	Experiment 1		Experiment 2	
	Feed/hen/day (gms.)	Body weight* (gms.)	Feed/hen/day (gms.)	Body weight* (gms.)
0.02	51.4[a]	1288[a]	70.1[a]	1381[a]
0.06	52.3[a]	1378[a]	68.5[a]	1431[a]
0.06 + progesterone**	68.0[b]	1512[a]	72.4[a]	1422[a]
0.10	55.1[a]	1353[a]	72.6[a]	1423[a]
0.10 + progesterone**	75.4[c]	1584[b]	73.4[a]	1406[a]
0.18	55.5[a]	1361[a]	75.0[a]	1372[a]
0.54	59.6[ab]	1420[a]	81.3[a]	1454[a]
3.00	93.2[d]	1612[b]	103.7[b]	1633[b]

* Means with different superscripts are significantly different according to Duncan's multiple range test ($P < 0.05$).
** 6 chloro Δ^6-17-acetoxy progesterone.

to be the critical level of calcium for the production of eggs since this group laid at the rate of about 15%. This finding agrees with an earlier report by Douglas *et al.* (1972).

Feed consumption (Table 3) tended to increase with increasing levels of calcium. This increase was not found to be statistically significant until the level of calcium was increased to 3.0% in the diet. The birds receiving the diets containing progesterone consumed more feed than those on comparable levels of calcium without progesterone. This was especially true in the first experiment which was conducted during warm weather. This increase in feed consumption due to the inclusion of progesterone in the feed resulted in an increase in body weight. There was a marked difference in feed intake between experiment 1 and experiment 2 which was attributed to the colder weather when experiment 2 was conducted.

A highly significant correlation coefficient of + 0.412 was found between tibia breaking strength and body weight. This would indicate that the larger hens with corresponding larger bones have stronger bones. This is probably due primarily to the greater diameter of the bones.

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