Ca RETENTION IN YOUNG PULLETS AND LAYING HENS FED A Ca^{47} LABELLED DIET OF DIFFERENT Ca LEVELS

K. BRONSCH, K. LÖRCHER and J. VILLWOCK

Institut für Tierzucht und Tierernährung
der Freien Universität, 1 Berlin 33, Brümmerstrasse 34 (West Germany)

INTRODUCTION

Calcium is thought to be the first limiting factor in egg-shell formation. Numerous research work therefore has been carried out to investigate quantitatively the various processes involved in calcium metabolism of the laying hen.

Only since radioactive calcium isotopes have become available has it been possible to follow the pathway of dietary or endogenous calcium as well as to describe the dynamics of calcium metabolism.

It is not the scope of this paper to review all the well known publications dealing with retention and egg-shell incorporation of labelled calcium ; the results published in this field were discussed in detail elsewhere (BRONSCH *et al.*, 1967 ; LÖRCHER und BRONSCH, 1967 ; SCHNEIDER, 1967). The primary purpose of this report is to present further data on overall utilization of dietary calcium in pullets and laying hens.

EXPERIMENTAL

The present study consisted of four trials. 60 HNL pullets were randomly divided into 3 groups fed various levels of dietary calcium. A basal diet poor in calcium but otherwise optimal was supplemented with $CaCO_3$ and Na_2HPO_4 as seen below :

	Ca %	P %	Group I		Group II		Group III	
			Total Ca %	Total P %	Total Ca %	Total P %	Total Ca %	Total P %
Basal diet for pullets..	0.38	0.49	0.5	0.6	1.0	0.6	2.0	0.6
Basal diet for layers ..	0.43	0.54	2.0	0.7	3.0	0.7	4.0	0.7

$CaCO_3$ supplement of the diet was replaced by Ca^{47} labelled Calcium-carbonate (10 μCi Ca^{47}/kg feed) ; $Cr^{51}O_3$ which is not absorbed from the gut was used as a marker (100 μCi Cr^{51}/kg feed).

The double labelled diet was fed for 10 1/2 hours when the animals were 17 weeks (trial 1), 19 weeks (trial 2), 8 months (trial 3) and 15 months old (trial 4).

All birds were kept in individual laying cages. Feed and water were supplied *ad libitum*.

During the balance period feed consumption was determined separately for every subgroup (3-5 animals). The droppings were collected and pooled for every subgroup up to the 55th hour from the beginning of the labelled feeding. In trial 3_a droppings of four animals per group were collected individually and more frequently in order to determine the Ca* retention in relation to egg shell calcification.

Samples of feed and excreta were dried, ashed and the content of Ca^{47} and Cr^{51} analyzed by gamma spectrometry (Three Channel Autogamma System of Packard Instr. Comp. Inc.).

Ca* excretion was obtained as the ratio of administered Ca^{47} to Cr^{51}. These ratios can be expressed as percentage of Ca* retained by subtracting from one (ratio of administered Ca^{47} to Cr^{51}) and multiplying by 100.

RESULTS

Ca* retained as percentage of Ca* intake up to the 55th hour from the beginning of the labelled feeding is presented in table 1-4. If we assume the calcium in the basal diet to be absorbed to the same extent as the supplemented $CaCO_3$ one may calculate

TABLE I

Ca retention in 17 weeks old pullets fed a Ca^{47} labelled diet containing different levels of Calcium*

Dietary Ca %	Group (20 animals)	Ca* intake (1) per animal g	Ca* retention (2) %	Ca* retention per animal g
0.49	I	0.41 ± 0.02	41.3 *a*) ± 5.4	0.17 *a*) ± 0.02
1.09	II	0.93 ± 0.07	28.6 *b*) ± 2.2	0.27 *b*) ± 0.04
2.10	III	1.94 ± 0.17	18.2 *c*) ± 0.9	0.35 *c*) ± 0.02

(1) Ca* intake = intake of total Calcium from a Ca^{47} labelled diet fed for 10 1/2 hrs.

(2) Ca* retention = Ca* intake minus fecal Ca* excretion up to the 55th hour from the beginning of the labelled feeding.

a), *b*), *c*) : Mean values having different indices are significantly different ($p < 0.01$).

the amount of total calcium retained from the labelled diet. This was done in all subgroups and the results are shown in the last column of the tables 1-4.

In 17 weeks old pullets fed 0.5 (I), 1 (II) and 2 per cent (III) dietary calcium, Ca* retention was 41.3 (I) 28.6 (II) and 18.2 p. 100 (III) respectively. Total Ca retention of the labelled diet, however, was absolutely higher in group II and III compared with that of group I (table 1). This indicates that Ca retention rates given as percentage always should be considered with respect to Ca intake on dietary calcium level.

TABLE 2

Ca retention in 19 weeks old starting pullets fed a Ca[47] labelled diet containing different levels of Calcium*

Dietary Ca (%)	Group (5 animals per subgroup)		No of laying birds	No of eggs ([3]) laid during the trial	Ca* intake ([1]) per animal (g)	Ca* retention ([2]) (%)	Ca* retention per animal (g)
0.49	I	A	—	—	0.41	47.5	0.20
		B	1	2	0.37	51.2	0.19
		C	2	4	0.39	58.5	0.23
		D	—	—	0.34	56.1	0.19
1.09	II	A	2	2	0.77	38.3	0.29
		B	1	1	0.85	32.6	0.28
		C	2	3	0.79	43.3	0.34
		D	2	3	0.81	42.1	0.34
2.10	III	A	1	1	1.60	19.3	0.31
		B	3	5	1.45	35.6	0.52
		C	—	—	1.33	16.0	0.21
		D	4	12	1.91	53.0	1.01

([1]) ([2]) For index-explanation see tabl. 1.
([3]) Eggs laid up to the 72nd hr from the beginning of the labelled feeding.

TABLE 3

Ca retention in 8 months old laying hens*

Dietary Ca (%)	Group (4 animals per subgroup)		No of non laying birds (4) during the trial	No of eggs (3) laid per group during the trial	Ca* intake (1) per animal (g)	Ca* retention (2) (%)	Ca* retention per animal (g)
2.08	I	A	—	11	2.08	75.1	1.56
		B	—	11	1.98	74.9	1.48
		C	1	7	1.64	63.7	1.04
		D	1	6	1.63	61.5	1.00
3.03	II	A	—	11	2.93	58.3	1.71
		B	—	11	3.08	60.0	1.85
		C	—	10	3.05	58.5	1.79
		D	—	11	3.04	61.9	1.88
4.05	III	A	—	12	3.96	52.7	2.09
		B	—	12	3.61	58.1	2.10
		C	1	8	3.24	45.9	1.49
		D	—	11	3.53	59.2	2.09

(1) (2) (3) For explanation see tabl. 1 and 2.

(4) Hens having not laid an egg up to the 72nd hr from the beginning of the labelled feeding.

TABLE 4

Ca retention in 15 months old laying hens*

Dietary Ca (%)	Group		Birds per subgroup	No of eggs (3) laid per group during the trial	Ca* intake (1) per animal (g)	Ca* retention (2) (%)	Ca* retention per animal (g)
2.08	I	A	4	11	1.59	77.3	1.23
		B	4	8	1.34	65.4	0.88
		C	5	11	1.45	68.1	0.99
		D	4	3	1.52	46.6	0.71
3.03	II	A	4	10	2.30	51.1	1.18
		B	5	13	2.77	38.9	1.08
		C	4	9	2.51	32.4	0.81
		D	5	10	2.57	44.7	1.15
4.05	III	A	3	7	2.84	23.0	0.65
		B	5	9	3.14	39.5	1.24
		C	4	7	2.75	22.4	0.62
		D	3	5	2.65	24.1	0.64

(1) (2) (3) For explanation see tabl. 1 and 2.

TABLE 5

Labelled Calcium in egg-shells as percentage of total egg-shell Calcium

	Group I			Group II			Group III		
	Ca* in egg-shell (% of total egg shell-Ca)	No of eggs	Ca/egg-shell (g)	Ca* in egg shell (% of total egg-shell-Ca)	No of eggs	Ca/egg-shell (g)	Ca* in egg-shell (% of total egg-shell-Ca)	No of eggs	Ca/egg-shell (g)
8 months old layers									
1st eggs	4.4 ± 4.4	7	1.67	2.8 ± 2.1	11	1.85	3.0 ± 3.0	10	1.81
2nd eggs	62.0 ± 10.3	11	1.64	63.3 ± 7.4	13	1.78	68.8 ± 9.9	13	1.67
3rd eggs	9.0 ± 2.5	10	1.70	7.5 ± 2.3	13	1.86	8.2 ± 1.6	12	1.77
15 months old layers									
1st eggs	2.5 ± 3.6	10	1.57	4.2 ± 4.7	15	1.69	1.3 ± 1.0	8	1.61
2nd eggs	33.2 ± 7.2	11	1.63	35.4 ± 6.6	13	1.84	30.4 ± 5.1	9	1.93
3rd eggs	6.1 ± 1.0	12	1.57	4.5 ± 1.3	13	1.89	3.7 ± 1.2	6	2.00

Two weeks later, the birds started laying. According to egg production Ca* retention increased in all groups (table 2).

It should be pointed out that Ca* retention increased too in subgroup I A and I D although none of the birds were laying yet. This may be interpreted with respect to formation of medullary bone. On the other hand the non laying hens in group III C showed no increase of Ca* retention indicating that the amount of calcium retained seemed to be sufficient for calcification of medullary bone.

High producing layers 8 months old fed 2 (I), 3 (II) and 4 percent (III) of dietary calcium retained

61.5 — 75.1 p. 100 = 1.0 — 1.56 g (I)
58.3 — 61.9 p. 100 = 1.71 — 1.88 g (II)
and 49.9 — 59.2 p. 100 = 1.49 — 2.1 g (III)

of labelled calcium (table 3).

The effect of both egg production and dietary calcium on Ca* retention is clearly demonstrated by the data given in table 3 and 4.

When the birds were 15 months old, egg production and consequently Ca* -retention were reduced significantly in group III fed 4 p. 100 dietary calcium. Ca retention of the labelled diet, however, was decreased too in almost all other groups due to a probably lower Ca-absorption rate towards the end of the laying season (table 4).

Ca^{47}/Cr^{51} ratio changes significantly in various fractions of droppings collected with respect to egg shell formation in single hens. The ratio was high in samples excreted up to the 8th hour after oviposition whereas it was low during egg shell calcification. This indicates either an increased Ca* absorption or a decrease in Ca* excretion of absorbed Ca* via the kidneys or both during egg shell mineralization.

In table 5 the deposition of calcium from the labelled diet in the egg shells is presented as percentage of total egg shell calcium. Only small amounts of Ca* were deposited in the first eggs laid a few hours after the beginning of the labelled feeding. The highest Ca* content was observed in the second laid eggs : in eight months old layers more than 60 p. 100 of the egg shell calcium derived from labelled calcium ; only half of that was analyzed in the 2nd eggs when the hens were 15 months old.

The deposition of Ca* in the first three eggs expressed as percentage of retained calcium from the labelled diet is summarized in table 6. Compared to the 8 months old birds the older layers used the Ca* retained to a less extent for egg shell mineralization.

TABLE 6

Deposition of labelled Calcium (Ca*) *as percentage of retained Calcium*(Ca*)

Group	8 months old layers			15 months old layers		
	Ca* egg-shell % of Ca* retained	No of eggs	No of layers	Ca* egg-shell % of Ca* retained	No of eggs	No of layers
I	69.4	30	16	49.7	33	16
II.	66.3	40	16	50.3	42	18
III.....	66.6	37	16	57.1	28	14

SUMMARY

Retention of labelled dietary calcium was determined in 60 animals (HNL) using the Ca^{47}/Cr^{51} ratio technique.

The labelled diet was fed for 10.5 hours when the birds were 17 and 19 weeks, 8 and 15 months old. Ca* retention was determined up to the 55th hour from the beginning of the labelled feeding.

The results indicate that Ca* retention depends very much on egg production and also on dietary calcium level.

17 weeks old pullets fed 0.5 (I), 1.0 (II) and 2.0 p. 100 (III) dietary calcium retained 41.3 p. 100 = 0.17 g (I), 28.6 p. 100 = 0.27 g (II) and 18.2 p. 100 = 0.35 g (III) of labelled calcium. 19 weeks old hens started laying, and Ca* retention was increased in all groups according to egg production.

8 months old laying hens fed 2 (I), 3 (II) and 4 p. 100 (III) dietary calcium retained :

61.5 — 75.1 p. 100 = 1.0 — 1.56 g (I)
58.3 — 61.9 p. 100 = 1.71 — 1.88 g (II)
and 45.9 — 59.2 p. 100 = 1.49 — 2.1 g (III)

of labelled calcium.

Due to the lower egg production in 15 months old hens Ca* intake as well as Ca* retention were decreased.

Labelled calcium as a percentage of total egg shell calcium was highest in the second laid egg after labelled feeding.

Approximately 66 p. 100 (8 months old hens) and 50 p. 100 (15 months old hens) of the Ca* retained were deposited in the first three eggs laid after labelled feeding.

Ca^{47}/Cr^{51} ratios were significantly lower in fractions of droppings excreted during egg shell mineralization.

RÉSUMÉ

RÉTENTION DU Ca CHEZ LA POULETTE ET LA PONDEUSE NOURRIES AVEC UN RÉGIME MARQUÉ AU ^{47}Ca ET A TAUX CALCIQUE VARIABLE

La rétention du calcium alimentaire marqué a été déterminée chez 60 animaux (HNL) en utilisant la technique du rapport $^{47}Ca/^{51}Cr$.

Le régime marqué a été fourni durant 10,5 heures à des oiseaux âgés de 17 et 19 semaines, 8 et 15 mois. La rétention de Ca* a été déterminée jusqu'à la 55e heure suivant le début de l'administration du régime marqué.

Les résultats indiquent que la rétention de Ca* dépend beaucoup du taux de ponte et aussi de la teneur en calcium du régime.

Des poulettes âgées de 17 semaines et recevant 0,5 (I), 1,0 (II) et 2, op. 100 (III) de calcium alimentaire ont retenu 41,3 p. 100 = 0,17 g (I) ; 28,6 p. 100 = 0,27 g (II) et 18,2 p. 100 = 0,35 g (III) de calcium marqué.

Chez les poules de 19 semaines commençant à pondre, la rétention de Ca* était accrue dans tous les groupes en fonction du taux de ponte.

Des poules pondeuses âgées de 8 mois et recevant 2 (I), 3 (II) et 4 p. 100 (III) de calcium alimentaire ont retenu les quantités suivantes de calcium marqué :

61,5 — 75,1 p. 100 = 1,00 — 1,56 g (I)
58,3 — 61,9 p. 100 = 1,71 — 1,88 g (II)
et 45,9 — 59,2 p. 100 = 1,49 — 2,10 g (III)

La diminution de l'ingestion et de la rétention de Ca* chez les poules âgées de 15 mois était due au taux de ponte plus faible.

Le pourcentage de Ca* dans le calcium total de la coquille de l'œuf était plus élevé pour le second œuf produit après l'administration du régime marqué.

Environ 66 p. 100 (poules de 8 mois) et 50 p. 100 (poules de 15 mois) du Ca* retenu a été déposé dans les trois premiers œufs pondus après la période d'alimentation marquée.

Les rapports $^{47}Ca/^{51}Cr$ étaient significativement plus faibles dans les fractions excrétées durant la minéralisation de la coquille de l'œuf.

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