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RELATIONSHIP BETWEEN PHOSPHORUS LEVEL AND FEED ALLOWANCE OF DWARF BREEDERS WITH EGG QUALITY AND BONE DEVELOPMENT OF DAY OLD CHICK

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ABSTRACT

An experiment was conducted to study the relationship between dietary levels of phosphorus level and feed allowance of dwarf breeder hens on the egg quality and the bone development of day old chick. One hundred and forty-four broiler breeders were kept in battery cages. Birds were fed (2.750 kcal/kg ME and 16.5% CP) either 105 and 115 g/day containing of 0.2; 0.6 and 1.0 % available phosphorus. The result indicated that egg weight was decreased by limiting the feed intake of the breeders. Shell quality decreased in proportion to the dietary phosphorus levels and was not affected by feed allowance. Albumen quality was slightly impaired in severely restricted hens. Serum inorganic phosphorus in hens and yolk phosphorus increased with dietary phosphorus levels, but it was not found in serum inorganic phosphorus in day old chicks. Tibia ash percent of the progeny at hatching was markedly improved in proportion to maternal phosphorus and feed intake. It was concluded that maternal feed intake and phosphorus supplies are of importance for the egg quality and initial bone development of the progeny.

Key words: Relationship, Phosphorus level, Feed allowance, Dwarf breeders, Egg quality, Bone development, Day old chick

INTRODUCTION

In birds, both embryonic growth and development are totally dependent upon the constituent of the egg. Maternal diet could be of importance on bone ossification of the progeny. Vitamin or mineral deficiency or sub deficiency can increase the incidence of leg problems (Whitehead, 1989) or produce embryos suffering bone malformations (Beer, 1969). Literature relative to the effects of parental nutrition on bone development of the offspring is very limited and breeder's nutritional recommendations are established on breeders' performance taking little account of the quality of the offspring.

Restricted feeding during the rearing and laying periods is a common practice in breeders to minimise the costs of production and because it has been demonstrated that quantitative feed restriction improves performance and fertility of breeders (Pearson and Herron, 1982; Wilson and Harms, 1984; Robbins *et al.*, 1988). Egg weight decreases with lower feed allowance (Pearson and Herron, 1985; Tri-Yuwanta and Nys, 1990) but may also be unaffected under limited restriction (Wilson and Harms, 1984; Robbins *et al.*, 1988). One-day-old chick weight is correlated with egg weight (Al-Murrani, 1978, Spratt and Leeson, 1987). However, its influence on bone growth has not yet been evaluated, this evaluation was the first objective of the present study.

Maternal mineral nutrition influences also hatchability and embryo development (Beer, 1969). Hatchability of fertile eggs is depressed in caged hens fed on 0.19% total phosphorus diet and is normal with 0.3% total phosphorus (Singsen *et al.*, 1962). Higher levels of total phosphorus (0.31 to 1.42%) have no effect on hatchability (El Boushy, 1979; Wilson *et al.*, 1980) but shell quality decreases with the increase in phosphorus level (El Boushy, 1979; Miles, 1980; Roland Sr., 1989, Pan *et al.*, 1998). In broilers,

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percent ash and breaking strength of the tibia increase with dietary phosphorus (Yoshida and Hoshii, 1982, Sell and Jeffrey, 1997 and Pan *et al.*, 1998) and the question arises of an effect of breeder hens phosphorus intake on the ossification of the embryo. El Boushy (1979) showed that maternal phosphorus supplementation has little effects on ash tibia content of one-day-old chicks.

The second objective of the present study was to further examine the relationship between maternal phosphorus levels on the performance of dwarf broiler hens and their progeny, and especially to evaluate its consequences on bone ossification of day old chick.

MATERIALS AND METHODS

Experiment was conducted in Station de Recherches Avicoles, INRA Centre de Tours (France). One hundred and forty four ISA Vedette dwarf broiler breeder hens were reared in individual cages in 2 rooms containing 72 cages/room. A design of 2 (feed intake levels) x 3 (phosphorus levels) factorial arrangement of treatments with 4 replicates of 6 hens/replicate was used in this experiment. Hens were fed (2.750 kcal/kg ME and 16.5% CP) either 105 or 115 g/day with an experimental breeder diet containing either 0.2 or 0.6 or 1.0 % phosphorus. Water was distributed unlimited.

At 28 weeks of age and every 10 weeks thereafter, three consecutive eggs laid by hen were collected. Egg weight, Haugh units, shell weight and shell index (g shell/dm2) were measured using the E.Q.M system (Yolancen Ltd., York YO1 1DW, England). Shell breaking strength was measured with an Instron testing machine (model no. 1140, Instron S.A. Brick 78, France).

Bone ash of right side of day old chick tibias was determined. Bones were boiled for one hour and defatted with ethanol for 24 h. After drying at 110 ^{0}C for 14 h, mineralization was carried out at 550 ^{0}C for one night. At the end of the trial, blood samples were taken by heart puncture for day old chicks or from the wing vein for adult hens (8 hens/treatment). Serum inorganic phosphorus levels were determined by colorimetry using a technicon auto analyser. Total phosphorus levels in egg constituents were analysed from 6 eggs/treatment at 58 weeks of age. Eggs were broken out and separated into yolk, white and shell. The internal constituents were lyophilised then mineralised at 550 ^{0}C for 14 h. The ash was dissolved in 20% nitric acid and phosphorus content was determined by colorimetry. Tibial ash content was evaluated from 10 breeder hens per group at the end of the assay.

Data were analysed by analyses of variance using the general linear model procedures and computed using SYSTAT (Williamson, Leland, Systat Inc. Evanston, USA). The tested effects were feed restriction, phosphorus level, and their interactions.

RESULTS AND DISCUSION

The present experiment does not only show that both feed and phosphorus levels affect egg quality but also demonstrates that these changes in maternal nutrition influence on plasma inorganic phosphorus of breeders and day old chick and bone development of the offspring.

Egg weight increased ($P<.01$, Table 1) in hens fed the higher feed allowance, but was unaffected by phosphorus levels. Results from this experiment support the previous findings (Pearson and Herron, 1985; Tri-Yuwanta and Nys, 1990, Tri-Yuwanta *et al.*, 1992) that egg weight increases with feed allowance. Albumen quality was modified by feed restriction. Albumen quality as measured by Haugh units was slightly higher with a 115 g/d feed restriction than that with a 105 g/d as shown in a previous experiment (Tri-Yuwanta *et al.*, 1992). Increasing phosphorus level in the diet depressed shell index ($P<.01$) and shell breaking strength ($P<.01$). However, shell quality was not influenced by feed allowance. An interaction between feed restriction and phosphorus level ($P<.05$) was observed in shell breaking strength. In the present work shell quality was not affected by

Table 1. Effect of feed allowance and phosphorus level on egg quality

Feed intake (g/bird/d)	Phosphorus level (%)	Egg weight (g)	Haugh Unit	Shell index (g/dm3)	Shell breaking strength (kg)
105	0.2	60.3[a]	88.9[a]	7.8[b]	2.5[c]
	0.6	60.2[a]	90.1[ab]	7.5[a]	2.3[ab]
	1.0	60.7[a]	90.6[ab]	7.5[a]	2.2[a]
115	0.2	61.9[ab]	91.0[b]	7.8[b]	2.4[bc]
	0.6	62.1[ab]	89.6[ab]	7.7[ab]	2.3[ab]
	1.0	62.4[b]	90.5[ab]	7.6[a]	2.2[a]
Probability Feed Intake		*	*	ns	ns
Phosphorus level		ns	ns	**	**
Interaction		ns	ns	ns	*

* Significant P<.05; ** Significant P<.01; n s: Not significant
[a,b,c] Values with different letters are significantly different P<.05

the level of feed restriction which was in agreement with most other studies (Robbins *et al.*, 1988; Tri-Yuwanta and Nys, 1990). In contrast, increases in dietary phosphorus content markedly depressed shell quality. This agrees with Roland (1989) observations conducted in egg type hens and with the findings by Wilson *et al.* (1980), and by El Boushy (1979) in breeder hens that it is increasing egg shell weights with higher dietary phosphorus levels.

The concentration of phosphorus was greater in yolks from hens fed the highest level of total phosphorus (P<.05, Table 2) as well as in eggs from hens fed 115 g/day versus 105 g/day (P<.05). The plasma inorganic phosphorus of breeder hens increased in parallel with the supply of dietary phosphorus to the hens (P<.01). Interactions between treatments were observed (P<.05) for plasma inorganic phosphorus. It is noteworthy that the difference in blood inorganic phosphorus of

Table 2. Effect of feed allowance and phosphorus level on phosphatemi and egg yolk phosphorus content

Feed intake (g/bird/d)	Phosphorus level (%)	Plasma inorganic phosphorus		Egg yolk phosphorus (mg/g)
		Breeder hens (mg/l)	One day old-chick (mg/l)	
105	0.2	18.6[a]	36.0	9.0[a]
	0.6	27.8[bc]	37.4	9.0[a]
	1.0	31.4[c]	40.8	9.7[b]
115	0.2	20.3[ab]	34.4	9.4[ab]
	0.6	26.4[b]	36.2	9.5[ab]
	1.0	31.1[c]	38.8	9.8[b]
Probability Feed Intake		ns	ns	*
Phosphorus level		*	ns	*
Interaction		*	ns	ns

Significant P<.05; ** Significant P<.01; ns: Not significant
[a,b,c]. Values with different letters are significantly different P<.05

day-old chicks showed the same tendency as the one from which these yolks were issued; however, none of these levels reached significance. Serum phosphorus levels in hens increased in parallel with bone phosphorus content. Such a relationship between blood inorganic phosphorus and its levels in the diet was previously demonstrated by Rodriguez *et al.* (1984), El Boushy (1979), and by Lima *et al.*, (1997), but Choi *et al.* (1979) observed no changes in blood phosphorus when dietary levels vary between 0.37 and 1.4%. The egg yolks reflected the changes in serum inorganic phosphorus but in one-day-old chick there was only a tendency of blood inorganic phosphorus to increase with maternal dietary phosphorus levels. Bone ash content of one day-old chick corresponded directly to maternal dietary phosphorus intake and to phosphorus content of the yolk. This is in contrast with previous findings by El Boushy (1979) Moreover, percent ash of one-day-old chick tibia increased with maternal feed allowance, in agreement with a previous report (Tri-Yuwanta *et al.*, 1992). This may be, at least in part, due to the improvement in chick weight at hatching associated with the increase in maternal energy and protein intake (Leclercq, 1985). The magnitude of one-day-old body weight increase with maternal feed allowance was however moderate as shown by other workers (Spratt and Leeson, 1987; Tri-Yuwanta and Nys, 1990). In the present experiment, increases in maternal mineral or vitamin supplies are more likely involved as such sub deficiencies have been demonstrated to affect bone development of the embryo (Beer, 1969; Whitehead, 1989). Here, both yolk phosphorus and its plasma inorganic phosphorus old day old chick content increased with maternal feed intake. If no supplementation is provided, an overall quantitative feed restriction influences all other nutrients intakes or on bone ash content (Tri-Yuwanta *et al.*, 1992).

From previous data, the effect of dietary phosphorus content on percent bone ash or tibia breaking strength is shown on Table 3. A low dietary phosphorus level decreases mineral content and maximal force of bone in hens (El Boushy, 1979; Garlich *et al.*, 1982, Sell and Jeffrey, 1997) but Mikaelian and Sell (1981) were unable to establish a significant positive effect of high dietary phosphorus on bone. However, the present work confirms previous observations by El Boushy (1979) that bone increases in proportion to dietary phosphorus level in breeder hens. Breeder hen tibias showed higher ash content in hens fed higher phosphorus levels (P<.01). Furthermore,

Table 3. Effect of feed allowance and phosphorus level on tibia ash of breeder and DOC

Feed intake (g/bird/d)	Phosphorus level (%)	Tibia quality of breeder		Tibia quality of day-old	
		Maximal force (N)	Tibia ash breeder (%)	Maximal force of (N)	Tibia ash of DOC (%)
105	0.2	138^{a}	55.2^{a}	5.4^{a}	33.2^{a}
	0.6	160^{ab}	58.0^{ab}	5.8^{ab}	35.2^{ab}
	1.0	177b	60.4^{b}	6.1^{b}	36.2^{bc}
115	0.2	131^{a}	55.9^{a}	5.5^{a}	34.0^{ab}
	0.6	153^{ab}	57.8^{ab}	6.0^{ab}	35.1^{ab}
	1.0	173^{b}	60.6^{b}	6.3^{b}	38.5^{c}
Probability Feed Intake		ns	ns	ns	*
Phosphorus level		**	**	**	*
Interaction		ns	ns	ns	ns

*Significant P<.05, ** Significant P<.01, ns Not Significant

^{a,b,c} Values with different letters are significantly different P<.05

N : Newton

increases in phosphorus levels and in feed allocation of maternal diets improved ash content (P<.01)

In conclusion, our results demonstrate that overall feed restriction and mineral content of the diet not only affect on egg quality of breeder hens but also interfere with bone composition and tibial strength of the progeny at day-old.

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