# A STUDY OF INTER-RELATIONSHIPS BETWEEN DIETARY LEVELS OF IRON PHOSPHORUS AND CALCIUM FOR THE CHICK

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ABSTRACT

A STUDY OF INTER-RELATIONSHIPS BETWEEN DIETARY LEVELS OF IRON, PHOSPHORUS AND CALCIUM FOR THE CHICK

Two experiments were conducted utilizing a semi-purified ration in which the major ingredients were corn starch, dextrose and dried egg white. Broiler type chicks were used in both experiments. In the first experiment (1262) a complete factorial arrangement of 6 ration treatments was used. The levels of iron (Fe) and phosphorus (P) studied were: 13, 26, and 39 p.p.m.; and 0.30 and 1.0% respectively. In the second experiment (1562), the following levels of iron, phosphorus and calcium (Ca) were tested: 16, 36, 56, 76, 96 p.p.m.; 0.10, 0.35, 0.60, 0.85 and 1.10%; and 0.20, 0.60, 1.0, 1.4, 1.8% respectively. A three dimensional, central composite design was used to assign the ration treatments.

In both experiments, weight gain proved to be a relatively poor criterion for iron status as compared to hemoglobin concentration (Hb). Both Fe and P exerted significant ($P \leq .01$) main effects on Hb in experiment 1262. At each level of dietary Fe, increasing the phosphorus level from 0.30 to 1.0% reduced Hb. Regardless of the P level, increasing the Fe level from 13 to 26 or to 39 p.p.m. increased Hb. Cytochrome c content of heart tissue failed to indicate any consistent trend related to Fe or P treatments. Changes in dietary Fe level failed to cause any significant effect on bone ash values. In experiment 1562, an increase

in dietary P, when Ca and Fe were held constant, resulted in a significant ($P \leq .05$) decrease in Hb. Simultaneously, added P, caused a reduction in the percent of dietary Fe retained. An increase in ration Ca, at a given P level, also reduced Hb when the rations contained 56 p.p.m. or less of Fe but exerted little influence on Fe retention. Varying the levels of Fe did not cause any consistent change in bone ash.

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# INTRODUCTION

Research in nutrition, particularly in the last decade, has devoted considerable attention to ways and means of increasing productivity of domestic animals through the use of new feed additives and adjustments in the quantities of essential nutrients included in the ration. Recently, much research has been conducted in an effort to re-evaluate the dietary requirement of domestic animals for various minerals. In this regard, Davis (1960) said;

"No longer is it possible to discuss (or study) any element in terms of its requirement without considering the other nutrients in the diet whether these be protein, carbohydrate, or other mineral elements ...

In the overall nutrition of human or animal a deficiency or toxic excess of any given element must be considered against the background of the levels of other nutrients which are present in the diet."

There has been much interest in the dietary inter-relationships between calcium and phosphorus, and trace elements such as magnesium, zinc, aluminium and iron. Most research on this subject has been done with rats, and much attention has been focused on the inter-relationships between either calcium or phosphorus and specific trace minerals. Consequently, little information is available concerning possible nutritionally important inter-relationships which may exist simultaneously between calcium, phosphorus and a specific trace mineral. It was the objective of this study, to examine the dietary inter-relationships between calcium, phosphorus and iron in the chicken. The study was conducted in two parts. Part 1 dealt with the effect of various phosphorus and iron levels (maintaining a constant calcium to phosphorus ratio) on weight gain, feed efficiency and blood components. Part 11 dealt with the effects of various combinations of calcium, phosphorus and iron levels, on weight gains, blood components and utilization of the three elements.

## REVIEW OF LITERATURE

Mineral inter-relationships have been the subject of numerous investigations. Pensack et al (1958 tested the effects of calcium and phosphorus on zinc requirements of chickens. Zinc levels of six, twenty and forty parts per million (p.p.m.) from varied sources were tested in combination with calcium: phosphorus ratios of 1.0:0.6, 2.0:0.6 and 1.0:1.2. The results showed that zinc was equally available from all sources tested and that neither excessive calcium nor excessive phosphorus deleteriously affected zinc availability. Roberson and Schaible (1960) also working with chicks found that 2.23 percent calcium in the ration caused significant growth depression and symptoms of zinc deficiency when zinc was present at 36 p.p.m. At the same level of calcium and 96 p.p.m. of zinc, growth was normal and zinc deficiency symptoms did not occur. A phosphorus level of 1.10 percent in the presence of either 36 or 96 p.p.m. of zinc did not significantly affect growth.

Forbes (1961) reported that calcium and phosphorus can have an adverse effect on magnesium utilization. Rats were used as experimental subjects in a balance trial employing a 3 x 3 factorial design. Weight gains were reported to be markedly depressed by excess calcium. On the other hand, phosphorus increased weight gains especially in the presence of high calcium levels while magnesium slightly improved weight gains. Visible symptoms of magnesium deficiency were most readily produced on high calcium - high phosphorus diets and were alleviated by magnesium supplementation. Magnesium balance was improved by added magnesium and by added phosphorus, but was adversely affected by added calcium when a low magnesium diet was fed. The calcium effect was slight on high magnesium diets. The data indicate that calcium was more detrimental than phosphorus to magnesium utilization. O'Dell (1960) also reported evidence of calcium, phosphorus and magnesium inter effects. Excess dietary magnesium was reported to have caused a loss of calcium from the body when the diet was low in phosphorus but not when phosphorus was adequate. Conversely, the consumption of excess calcium accentuated the symptoms of magnesium deficiency in an animal that consumed a deficient diet. O'Dell stated that there is evidence to show that excess phosphorus will substantially increase the magnesium requirement. Phosphorus was said to exert its effect chiefly by decreasing absorption of magnesium but there was limited evidence to suggest that it also had a direct metabolic effect.

Iron, Calcium and Phosphorus Inter-relationships

Cox et al (1931) reported that when guinea pigs were fed rations containing iron and/or aluminum salts, inorganic phosphorus levels in the blood were substantially lowered. The ash, calcium and phosphorus contents of the bones were reduced to seventy percent of normal after the diet containing aluminum had been fed for 12 weeks. Similiar but less marked effects when excess iron was fed were observed. The addition of mono-sodium phosphate equivalent (on a molar basis) to the level of aluminum or iron in the diet entirely prevented the occurrence of these symptoms. From these findings, it was postulated that aluminum and iron induced a phosphorus deficiency by precipitation of alimentary phosphorus as ferric and aluminum phosphates.

Deobald and Elvehjem (1935) performed similar work with chicks. Day-old chicks fed normal rations to which large amounts of soluble iron and aluminum salts (0.9 percent iron, 0.44 percent aluminum) were added developed severe rickets in one to two weeks and were all dead within three weeks. Levels of iron and aluminum salts equivalent to one half and three quarters of the amount necessary to unite with all the ration phosphorus to form insoluble ferrous phosphate and aluminum phosphate reduced bone ash to twenty-five percent and reduced blood phosphorus to 2-4 mg/100 cc. of serum at three weeks of age. The addition of sodium acid phosphate in amounts sufficient to unite with the added metals allowed rapid growth and normal bone formation.

Studies on the effect of ferric chloride on both calcium and phosphorus were performed by Rehm and Winters (1960). Using rats, these workers made comparisons of the amounts of total ash, calcium and phosphorus in the bodies of animals fed unsupplemented diets with the amounts in the bodies of animals fed a diet supplemented with enough ferric chloride to combine with one half the phosphorus of the diet. It was shown that the addition of ferric chloride considerably reduced the amounts of total ash, calcium, and phosphorus at the end of thirty days. These results were obtained even though food intake was equalized. It was concluded by the authors that large amounts of ferric chloride had a detrimental effect on calcium and phosphorus metabolism.

The detrimental effect of iron on calcium and phosphorus utilization appears to be one of mutual antagonism. Evidence of this in regard to calcium, was reported by Kletien (1940). The addition of one percent calcium carbonate