Pakistan Vet. J., 24(3): 2004

EFFECTS OF HIGH DIETARY CALCIUM AND LOW PHOSPHORUS ON URINARY SYSTEM OF BROILER CHICKS

M. Ansar, S. A. Khan, Z. I. Chaudhary, N. A. Mian[1], M. Y. Tipu and M. F. Rai
Department of Pathology, [1] Department of Animal Nutrition,
University of Veterinary and Animal Sciences, Lahore 54000-Pakistan

ABSTRACT

The present study was carried out to investigate the effects of high dietary calcium and low phosphorus on urinary system of broiler chicks. A total of 90 (day-old) broiler chicks were divided into three equal groups A, B and C. The chicks were reared for 42 days on three experimental rations. Calcium:phosphorus ratio in the feed for groups A, B and C was maintained as 1:0.5 (control), 2:0.5 and 3:0.5, respectively. Various parameters studied included serum calcium and phosphorus concentrations, FCR, kidney:body weight ratio, and pathological examination of urinary system. The birds fed on high dietary calcium and low phosphorus revealed hypercalcaemia and hypophosphataemia in their sera. The FCR and mean kidney:body weight ratio of treatment groups was higher than the control group. The urinary system of the treated birds, in general, displayed inflammatory lesions, showing abnormalities of colour, size, shape and texture of kidneys and ureters. The ureters also showed occlusion and distention. The microscopic examination of the kidneys showing gross pathological lesions revealed common histopathological changes in glomeruli, tubular cells and interlobular veins.

Key Words: Calcium, phosphorus, urinary system, broiler chicks.

INTRODUCTION

The development of poultry industry in Pakistan has faced serious setbacks of various types. Mineral imbalance, particularly of calcium and phosphorus, is one of such problems responsible for economic losses to farm holders, who often formulate the poultry rations themselves. The importance of calcium and phosphorus in poultry is quite obvious, as they constitute the major part of the mineral contents of the bones. Calcium and phosphorus are very closely related to each other, and the deficiency or excess of one can interfere with the proper utilization of the other.

The maintenance of calcium and phosphorus ratio as 1.0:0.5 is essential for performance of various functions in the body concerning these minerals. Only a small percentage of total body concentration of calcium and phosphorus is found in the blood, but their presence in extracellular fluids is essential. Calcium is needed for the ossification of bones, regulation of skeletal and cardiac muscle activity, activation of several enzymes, transmission of nerve impulses, controlling trans-membrane trafficking of various proteins, permeability of membranes, maintenance of osmotic pressure and pH etc. Likewise, phosphorus is an important constituent of bones, nucleic acids and phospholipids. Both calcium and phosphorus are eliminated from the body in secretions and excretions; however, kidney and intestine remove most of the excess (Coles, 1986).

These critical functions are performed only when calcium and phosphorus are maintained in a specific ratio of 2:1, that necessitates maintenance of different physiological mechanisms including secretions, excretions and resorption etc. The disturbed balance of these minerals in diet can result in various pathological conditions including renal failure and development of gout in chicken (Chang and Fun, 1992). High dietary calcium concentration causes nephrosis and visceral gout in broilers (Page *et al*., 1979).

The present study was aimed at ascertaining the effects of high dietary calcium and low phosphorus on the urinary system of the broilers.

MATERIALS AND METHODS

Experimental design

A total of 90 (day-old) broiler chicks were randomly divided into three equal groups A, B and C. All the chicks were reared upto 42 days, on three experimental rations. The ratio of calcium and phosphorus in the feed was maintained as 1.0:0.5, 2.0:0.5, or 3.0:0.5 for groups A, B and C, respectively. The group A served as control.

Sampling schedule

About 3 ml of blood was collected weekly from five birds in each group. The serum was separated, transferred to clean, sterile plastic tubes and stored at –20°C till used. At the end of experiment, birds were weighed and slaughtered to examine urinary system and samples from their kidneys were processed for histopathological studies.

Experimental parameters

The following parameters were studied:

Serum calcium and phosphorus concentrations

The serum calcium and phosphorus concentrations were determined by colorimetric method, using double beam spectrophotometer with commercial kit of RANDOX-Co., UK (Cat. No. CA590) and AMTEC-Co., UK (Cat. No. 112-2100), respectively.

Feed conversion ratio

At the end of the experiment, feed conversion ratio (FCR) was calculated, using the formula of Singh and Panda (1992).

Kidney:body weight ratio

At the end of the experiment, all birds were weighed and slaughtered. Their kidneys were removed and weighed for calculation of kidney:body weight ratio (Giamborne and Closser, 1990).

Pathological examination of urinary system

After slaughtering, all the birds were examined for the presence of gross lesions in the ureters and kidneys. The kidneys of the birds showing gross pathological lesions were subjected to histopathological examination, using the technique described by Drury and Wallington (1980).

Statistical analysis

The data obtained were statistically analyzed by applying one way analysis of variance and Least Significant Difference test (Steel and Torrie, 1982).

RESULTS AND DISCUSSION

The results of different parameters are presented in Tables 1-2. These results showed significantly higher ($P<0.05$) serum calcium concentration in group C fed high Ca:P ratio. This finding is in agreement to those of Ismail (1989), who observed higher serum calcium concentrations in birds fed high dietary calcium: phosphorus ratios. These findings also support the results of Chang and Fun (1992), who gave higher dietary concentration of calcium to birds and observed hypercalcaemia. Likewise, the work of Growth and Frey (1996) correlate strongly to the results of the present study, as they reported that even small deviation from optimal supply of calcium and phosphorus in diet produced changes in their respective levels in serum.

In our study, serum phosphorus level was significantly higher ($P<0.05$) in chicks of group A fed normal Ca:P ratio. These results indirectly indicate that a diet with increased calcium ratio induces hypo-phosphataemia. These findings are in agreement with the findings of Chang and Fun (1992), who studied pathology of chicken gout induced by high dietary calcium and low phosphorus. Similar results have been reported by Ismail (1989), and Ogura (1981), who studied pathology of the high dietary level of calcium in broiler chicks.

The lower FCR values of 2.089 and 1.876 were noted in groups C and B as compared to the group A (1.728). The low FCR was due to high dietary calcium and low phosphorus fed to experimental group birds while the comparatively better FCR was observed in group A where dietary ratio of calcium and phosphorus was normal. These findings are in agreement to those of Ismail (1989), who observed poor weight gain, decreased feed consumption and low FCR values in birds given a high dietary calcium and phosphorus ratio.

The values for kidney:body weight ratio for the groups A, B and C were 9.11, 11.95 and 16.08, respectively. These results showed that kidney:body weight ratio of treated groups was significantly higher than the control group. It may be inferred that the increased dietary calcium level caused structural and functional abnormalities in the kidneys of the experimental birds, leading to high kidney:body weight ratio. Priti *et al.* (2000) conducted an experiment to know the effects of high calcium and low phosphorus on cockerels maintained for 32 weeks. Though these workers did not work out the kidney:body weight ratio, yet kidney abnormalities including variation in size and weight of the organ were reported, which could alter the kidney:body weight ratio. Smith and Kobaija (1992) carried out toxicological evaluation of aflatoxin and cyclopiazonic acid given in feed to broiler chickens for a period of three weeks. The aflatoxin proved to be responsible for significantly increasing the relative weight of kidneys. However, both aflatoxin and cyclopiazonic acid contributed to significantly reducing the body weight gain of the birds.

The kidneys of experimental birds of groups B and C showed abnormalities of color, shape, size and texture with haemorrhages. The kidneys, in general, were swollen and larger in size. These changes were more marked in birds of group C, fed a dietary calcium:phosphorus ratio of 3:0.5, than those observed in group B birds, given a diet with calcium:phosphorus ratio of 2:0.5. Shane and Young (1969) reported renal and parathyroid changes in growing pullets fed high calcium in diet. Similarly, Glahn *et al*. (1988, 1989) observed gross kidney damage in birds fed high dietary calcium and low phosphorus.

Similar to kidneys, the ureters of birds in experimental groups B and C presented abnormalities of size, colour and texture and were haemorrhagic. Uric acid accumulation, occlusion and distention were also observed. These finings are in agreement to those of Page *et al*. (1979), who worked on toxicosis of calcium in birds and observed accumulation of uric acid in ureters and on the surface of viscera. The findings also get support from the study of Shane *et al*. (1968), who investigated the effect of different ratios of calcium in pullets. It was observed that the birds given 2.4 and 3.0% calcium diets developed uretral occlusion.

The histopathological changes included, ischaemic nature of glomeruli, with decreased cellularity and infiltration of mononuclear cells. Likewise, tubular cells were swollen with varying degrees of degenerative changes. Interlobular veins were dilated and multiple areas of petechial haemorrhages were observed in renal cortex. Ismail (1989) reported degenerative changes of Bowman's capsule, with cells showing necrosis. Similarly, certain areas of interlobular spaces showed fibrosis. Many workers have reported detrimental effects of high dietary calcium levels on urinary system of poultry birds. Page *et al*. (1979) observed nephrosis with calcium deposits in the renal tubular epithelium. Cortine and Gabriel (1972) reported onset of cellular degeneration in renal tubules and hyperplasia in certain zones of renal glomeruli. Shane and Young (1969) had varying observations of flattening of tubular epithelium to complete destruction of renal architecture. Moore *et al*. (1990) reported that, generally, many changes in cell function resulted from highly localized changes in calcium activity.

Table 1: Serum calcium (mean ± SE) levels of chickens (mg/dl) of three groups

Experimental weeks	Experimental groups/dietary Ca:P ratio		
	A /1.0:0.5	B /2.0:0.5	C /3.0:0.5
1st	$6.95^{a} \pm 0.230$	$8.10^{ba} \pm 0.367$	$8.21^{ca} \pm 0.325$
2nd	$8.04^{a} \pm 0.285$	$9.26^{ba} \pm 0.181$	$9.29^{ca} \pm 0.220$
3rd	$8.10^{a} \pm 0.329$	$11.21^{b} \pm 0.217$	$12.25^{c} \pm 0.255$
4th	$8.07^{a} \pm 0.291$	$11.27^{b} \pm 0.248$	$12.16^{c} \pm 0.256$
5th	$8.08^{a} \pm 0.341$	$11.36^{b} \pm 0.299$	$12.29^{c} \pm 0.241$
6th	$8.10^{a} \pm 0.348$	$11.25^{b} \pm 0.279$	$12.77^{c} \pm 0.169$

Values bearing different superscripts in a row differ significantly (P<0.05).

Table 2: Serum phosphorus (mean ± SE) levels of chickens (mg/dl) of three groups

Experimental weeks	Experimental groups/dietary Ca:P ratio		
	A /1.0:0.5	B /2.0:0.5	C /3.0:0.5
1st	$5.79^{a} \pm 0.230$	$4.02^{ba} \pm 0.351$	$3.95^{ca} \pm 0.334$
2nd	$6.27^{a} \pm 0.199$	$4.71^{ba} \pm 0.322$	$3.83^{ca} \pm 0.324$
3rd	$6.12^{a} \pm 0.322$	$4.82^{b} \pm 0.158$	$3.87^{c} \pm 0.293$
4th	$6.10^{a} \pm 0.437$	$4.68^{b} \pm 0.166$	$3.73^{c} \pm 0.129$
5th	$6.34^{a} \pm 0.154$	$4.33^{b} \pm 0.133$	$3.76^{c} \pm 0.103$
6th	$6.24^{a} \pm 0.178$	$4.31^{b} \pm 0.940$	$3.60^{c} \pm 0.144$

Values bearing different superscripts in a row differ significantly (P<0.05).

REFERENCES

Chang, J. K. and G. X. Fun, 1992. The pathology of chicken gout induced by high dietary calcium and low dietary phosphorus. Acta-Veterinaria-et-Zootechnica-Sinica, 23(1): 80-86.

Coles, E.H., 1986. Veterinary Clinical Pathology, 4th Ed. W.B. Saunder's Company Philadelphia, USA.

Cortine, M.M. and S. Gabriel, 1972. Effect of calcium in diet on the kidneys of broiler fowl. Serie Production Anim., 2: 17-26.

Drury, R.A.B. and E.A. Wallington, 1980. Carleton's Histopathological Techniques. 5th Ed., Oxford Univ. Press Oxford, UK.

Giamborne, J.J. and J. Closser, 1990. Efficacy of live vaccine against serologic subtypes of infectious bursal disease. Avian Dis., 34(7): 7-11.

Glahn, R.P., R.F. Wideman and B.S. Cowen, 1988. Effect of Gray infectious bronchitis virus and high dietary calcium on renal function of Single Comb White Leghorn pullets at 6, 10 and 18 weeks of age. Poult. Sci., 67(9): 1250-1263.

Glahn, R.P., R.F. Wideman and B.S. Cowen, 1989. Order of exposure to high dietary calcium and Gray strain infectious bronchitis virus alters renal function and the incidence of urolithiasis. Poult. Sci., 69(7): 1078-1086.

Growth, W. and H. Frey, 1996. Comparative study on effects of deficiency of calcium, phosphorus, or vitamin D on bones, blood and endocrine organs of chicks. Zentbl. Vet. Med., 13: 302-319.

Ismail M.R., 1989. A study of pathology of the higher dietary levels of calcium in broiler chicks. MSc Thesis, Deptt. Pathol. College of Veterinary Sciences, Lahore.

Moore, E. W. D., P.L. Becker, K.E. Fogarity, D.A. Williams, and F.S. Fay, 1990. Calcium imaging in single living cells. Theoratical and practical issues. Cell Calcium, 11(2/3): 157-179.

Ogura, Y., 1981. Leg abnormality associated with dietary excessive calcium carbonate in broiler chicks. National Institute of Animal Health Quarterly, Japan, 21(3): 141-147.

Page, R.K., O.J. Fletcher and P. Bush, 1979. Calcium toxicosis in broiler chicks. Avian Dis., 23(4): 1055-1059.

Priti, M., A.K. Dhabadgao, N. Arora, P. Mishra and N. Arora, 2000. Effect of dietary high calcium and low phosphorus on urolith formation and kidney damage. Indian J. Anim. Nutr., 17(4): 288-293.

Shane, S.M., R.J. Young and Leo-Lutwak, 1968. Avian nephrosis associated with high dietary calcium. Cornell Univ. Ithaca, New York, Fed. Proc., 27(2): 312.

Shane, S.M. and R.J. Young, 1969. Renal and parathyroid changes produced by high calcium intake in growing pullets. Avian Dis., 13: 558-567.

Singh, K.S and B. Panda, 1992. Feed efficiency, In: "Poultry Nutrition", 2nd Ed. Kalyam Publishers, Rajinder Nagar, India.

Smith, O.B. and E. Kobaija, 1992. Effect of high dietary calcium and wide calcium:phosphorus ratios in broiler diets. Poult. Sci., 64(9): 1713-1720.

Steel, R.G.D. and J.H. Torrie, 1982. Principles and Procedures of Statistics. 2nd Ed., McGraw Hill Book Co. Inc., NewYork, USA.