Acidic stress caused by dietary administration of citric acid in broiler chickens

R. Nourmohammadi and H. Khosravinia

Department of Animal Sciences, Lorestan University, Khorramabad, Lorestan, Iran

Correspondence to: R. Nourmohammadi (nourmohammadi.61@gmail.com)

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Abstract. Citric acid (CA) is commonly used in poultry diets to promote growth by acidifying the gastrointestinal contents, improving nutrient digestibility, and reducing pathogen loads; therefore, this study was conducted to demonstrate the effects of 0, 30 and 60 g of CA per kilogramme of diet on productive performance, selected blood metabolites, immune response and certain gut-related variables in broiler chickens using 150, 7-day-old Ross 308 male broiler chicks in five replicates of 10 birds each per diet. Growth performance, daily feed intake and tibia phosphorous (P) retention were significantly improved by the diets containing 30 g kg$^{-1}$ of CA ($P<0.01$) but were suppressed as CA increased to 60 g kg$^{-1}$. Dietary CA increased proventriculus, gizzard and ileum percentage and villus length, crypt depth and goblet cell number in duodenum, jejunum and ileum as well as ileal digestibility of crude protein, apparent metabolisable energy and total phosphorus while it decreased the pH of contents in the gut segments concerned ($P<0.01$). Diets containing 60 g kg$^{-1}$ of CA significantly reduced plasma P and Fe levels as well as cholesterol level and Alkaline phosphatase activity ($P<0.05$) while increasing the aspartate aminotransferase and lactate dehydrogenase activities ($P<0.01$) in the blood serum of the birds at day 42 of age. The percentage of bursa and thymus was greater in the birds fed on diets containing 60 and 30 g kg$^{-1}$ of CA, respectively ($P<0.01$). It was concluded that inclusion of 60 g kg$^{-1}$ of CA in the diet resulted in a severe reduction in performance, nutrient digestion and absorption and liver dysfunctions in broiler chickens, a phenomenon we call as acidic stress.

1 Introduction

Organic acids are presently well recognised as non-antibiotic feed additives in poultry nutrition (Windisch et al., 2008). These compounds are primarily used to prevent pathogen contamination such as *Salmonella* through sanitising the feed (Thompson and Hinton, 1997). However, experimental results showed that organic acids act to improve nutrient digestion and absorption, mucosal immunity and exert topical effects on the intestinal brush border in broiler chickens (Viveros et al., 2002). Kirchgessner and Roth (1982) reported that particular organic acids increase pepsin proteolysis secretion and enhance the release of gastrin and cholecystokinin hormones which regulate the digestion and absorption of proteins.

Citric acid (CA) is the most common organic acid used in poultry diets. It acts as a growth promoter through acidifying the gastrointestinal (GI) content and is considered as a favoured determinant in effective nutrient digestion. In addition, CA also improves the solubility of the feed ingredients, digestion and absorption of nutrients by modifying intestinal pH, (Centeno et al., 2007). Viveros et al. (2002) showed that dietary administration of acidifiers decreases the population of pathogenic bacteria and alters the nutrient uptake in favour of the host.

The first report, in the relevant literature, on administration of CA to animal diets was Shohl (1937), showed that rickets was prevented in rats fed a CA-/sodium citrate-supplemented diet deficient in Ca and P. The data lay dormant for almost 20 years until Pileggi et al. (1956) examined the effects of dietary organic acids in rats and showed that some compounds resulted in better performance while others had no positive effect. During the last 50 years, an increasing number of reports on the use of organic acids have appeared in the literature. As a result, organic acids such as lactic, propionic,