

EFFECT OF CITRIC ACID SUPPLEMENTATION ON GROWTH PERFORMANCE OF LARGE WHITE YORKSHIRE PIGS

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ABSTRACT

An experiment was conducted to study the effect of citric acid supplementation on growth performance of weaned LWY pigs up to market weight at 205 days. Thirty LWY weaned pigs were selected, divided randomly into five experimental groups and fed with five iso-nitrogenous and iso-calorie ad libitum diets, that contained citric acid at 0, 0.5 %, 1 % and 1.5 % and 2 % of feed. Feed intake was measured daily and body weight was recorded at fortnight intervals. The Escherichia coli count of excreta was estimated for all the weaned pigs for initial, middle and end of the experimental period. The weight gain was significantly ($p < 0.01$) increased by 2.61, 4.59 and 4.74 % at 1 %, 1.5 % and 2 % citric acid supplemented groups than control. The feed intake decreased ($p < 0.05$) and feed conversion efficiency improved ($p < 0.01$) in citric acid supplemented groups as compared to control. Best feed efficiency was observed in 1.5 and 2 % citric acid supplemented groups. The Escherichia coli count in feces was significantly ($p < 0.01$) decreased in citric acid supplemented groups than control and best results were observed in 1.5 and 2 % citric acid supplemented groups. It was concluded that the minimum level of citric acid supplementation at 1.5 % improved the growth performance and cost effectiveness to the maximum extent with lower faecal E. coli count in LWY pigs.

Key words: Citric acid, Feed efficiency, Feed intake, Pigs, Weight gain

INTRODUCTION

More number of feed additives is being commonly used in recent days in swine diet for improving the growth performance of pigs to exploit the genetic potential to the maximum extent (Bharathidhasan *et al.*, 2010). The feed additives available for pig production fall under various groups of

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antibiotics, chemotherapeutics, anthelmintics, feed enzymes, organic acids, probiotics, prebiotics and other growth-promoting agents.

The chemical nature and mode of action of feed additives are different to each other and selection of a specific feed additive and the level of optimal response also vary with the farm environment, management conditions and the physiological stage of the pig production (de Lange, 2010). Following the ban of antibiotics as growth promoter due to the antibiotic resistance, a need for an alternative to improve growth and efficiency of pig production has been realized (Xu *et al.*, 2021). This has impelled the scientific investigation of several feed additives and their ability to alter positively the gut health and function (Yan and Kim, 2013). In current years, public concern over development of resistant pathogenic strains and antibiotic residue in animal products has intensified the search for alternative materials for antibiotics in animal industry. A possible alternative for antibiotics is organic acids which are normally used as an acidifier in animal feeds for improving nutrient digestibility and growth performance of pigs.

The positive effect of organic acid supplementation directly improves the gut health and productivity by the way of antimicrobial activity, lowering the pH of digesta in stomach aiding protein digestion, reducing the emptying rate of stomach, stimulating enzyme (pancreatic) production and activity in the small intestine and providing nutrients to intestinal tissue thereby enhancing the mucosal integrity and function (de Lange *et al.*, 2010). Different combinations of organic acids (Ahmed *et al.*, 2014) and inorganic acids

are used increasingly in diets for weaning as well as growing cum finishing pigs and sows due to their beneficial and synergistic effects. The combination of organic acid and medium chain fatty acid has been reported to have beneficial effect in the intestinal micro ecology of antimicrobial strength in piglets (Zentek *et al.*, 2013). Earlier study also reported that the organic acid supplementation in pig diet has beneficial effects in swine performance (Wang *et al.*, 2009). Further, Partanen and Morz (1999) reported that the inclusion of organic acids in the diet can enhance the growth performance and modulate the intestinal microbiota in pigs. The citric acid is one of the important organic acids when fed to the piglets at 2 % level improved the weight gain with reduction of *E.coli* count in the faecal material and reduced mortality (Rita Narayanan *et al.*, 2008). The citric acid supplementation at 0.9 % was also improved the digestibility and growth performance of weaned pigs (Suriyanarayana *et al.*, 2014). However, there are a limited number of studies on the effect of citric acid supplementation on growth performance of pigs. Hence, the preset study was carried out to evaluate the effect of citric acid supplementation on weight gain, feed intake and feed efficiency of weaned Large White Yorkshire (LYW) pigs.

METHODOLOGY

Five types of *iso-nitrogenous* and *iso-calorie* experimental diets were prepared (NRC, 1998) and added with citric acid at 0, 0.5 %, 1 %, 1.5 % and 2 % of basal diet. Thirty LWY weaned pigs were weighed individually, ear tagged, distributed equally and randomly to five different experimental diets. The ingredient and chemical composition of the

grower (up to 20 kg body weight) and finisher diets (20-60 kg body weight) (AOAC, 2000) are presented in the Table 1. The pigs were reared under standard managerial practices in individual sty and provided with free access to water. Feed intake was measured daily and body weight was recorded at fortnight from the age at 70th day to 205th day of pigs. Relative economics was worked out based on the actual

cost of feed and cost of supplementation of citric acid. The *E.coli* count of excreta was estimated for all the weaned pigs by pour plate method using MacConkey agar in three times (initial (70th day), middle (140th day) and end of the experimental period (205th day) in fecal samples collected from the weaned pigs. The data collected on various parameters were statistically (Completely Randomized Design) analysed as per Snedecor and Cochran (1989).

Table 1: Ingredient and chemical composition of experimental pig diet

Ingredient (%)	Grower up to 20 kg BW	Finisher 20-60 kg BW
Maize	66	72
Soya bean meal	20	15
Sunflower meal	2	5
Wheat bran	5.5	5.5
Fish meal	4	-
Mineral mixture	2	2
Salt	0.5	0.5
Total	100	100
Chemical composition (%)		
Dry matter	91.6	91.50
Crude protein	18.12	15.07
Crude fibre	6.47	6.33
Non-starch polysaccharides (NSPs)*	11.72	12.10
Soluble NSPs*	0.77	0.75
In Soluble NSPs*	10.96	11.31
Calcium	0.9	0.68
Phosphorus	0.74	0.65
Available Phosphorus*	0.35	0.26
Cystine +methionine*	0.65	0.53
Lysine*	1.01	0.7
Methionine*	0.28	0.27
ME (kcal/kg)*	3194	3185
DE (kcal/kg)*	3359	3336

1. Mineral mixture per kg feed added and supplied calcium-6.4 g, phosphorus-1.2 mg manganese-55 mg, iodine-2 mg, zinc-52 g, copper-2 mg and iron-20 mg

2. The citric acid was added at the level of 0, 0.5, 1.0, 1.5 and 2.0% of grower and finisher diets

* Calculated values

RESULTS AND DISCUSSION

The data on the effect of supplementing citric acid on weight gain, feed intake, feed efficiency and cost effectiveness are presented in Table 2. The weight gain was significantly ($p<0.01$) increased by 2.61, 4.42 and 4.74 % at 1, 1.5 and 2 % citric acid supplemented groups respectively than control. It was observed that when the level of citric acid increased, the weight gain also increased in LWY pigs. The feed intake was significantly ($p<0.05$) decreased in all the citric acid supplemented groups than control. The decrease was 1.32, 4.39, 4.99 and 4.71 % in 0.5, 1.0, 1.5 and 2.0 % citric acid supplemented groups respectively than control. The feed efficiency was significantly ($p<0.01$) improved by 3.43, 7.06, 9.48 and 9.48 % in 0.5, 1.0, 1.5 and 2.0 % citric acid supplemented groups than

control. The minimum level at 1.5 % citric acid supplementation, increased the weight gain, decreased the feed intake and improves the feed efficiency to the maximum extent when compared to other treatment groups.

Similarly, Suryanarayana and Suresh (2014) observed that the citric acid supplementation at 0.9 % significantly ($P<0.01$) increased the average daily gain by 5.17 % than control in weaned pigs. They also observed that a non significant lower feed intake and a significant ($P<0.01$) improvement on feed: gain ratio in 0.9 % citric acid supplemented group than control. The present results are also consistent with Partanen and Morz (1999), who reported that the formic acid and its salts improved the average daily gain of weaned piglets and reduced the feed: gain ratio relative to non-acidified control group. Organic

Table 2. Effect of citric acid supplementation on growth performance of LWY pigs (Mean \pm S.E) (n=6)

Parameters	Citric acid (%)				
	0	0.5	1.0	1.5	2
Initial BW at 70 days (kg)	17.41 \pm 0.10	17.42 \pm 0.13	17.36 \pm 0.08	17.48 \pm 0.08	17.43 \pm 0.10
Final BW at 205 days (kg)	62.20 \pm 0.21	62.95 \pm 0.09	63.33 \pm 0.11	64.33 \pm 0.30	64.44 \pm 0.22
Weight gain (kg)*	44.78 \pm 0.20 ^a	45.53 \pm 0.16 ^{ab}	45.98 \pm 0.16 ^{bc}	46.85 \pm 0.36 ^{cd}	47.01 \pm 0.28 ^d
Feed Intake (kg)**	221.46 \pm 0.16 ^d	218.53 \pm 0.17 ^c	211.74 \pm 0.25 ^b	210.40 \pm 0.27 ^a	211.03 \pm 0.42 ^{ab}
Feed Efficiency*	4.96 \pm 0.02 ^d	4.79 \pm 0.02 ^c	4.61 \pm 0.02 ^b	4.49 \pm 0.03 ^a	4.49 \pm 0.02 ^a
Average daily gain (g)	300.54	305.57	308.59	314.42	315.50
Average daily feed intake (kg)	1.49	1.47	1.42	1.41	1.42
Cost of feed per kg weight gain (Rs.)	91.76	91.01	89.89	89.80	92.05

*Means bearing different superscript in the same row differs significantly ($p<0.01$)

** Means bearing different superscript in the same row differs significantly ($p<0.05$)

acids are both bacteriostatic and bactericidal. The exposure to an organic acid over a period can kill the cell (Luckstadt and Mellor, 2010) and this could be the probable reason in the present study for the citric acid fed pig groups to show improved performance, which could be achieved by competitive exclusion of the pathogenic bacteria for the nutrients. Further, the citric acid was lowered the gastric pH and improved the protein digestion by activating pepsin in stomach and improving the growth rate of piglets (Suryanarayana *et al.*, 2012) could also be the other possible reason of the increase in weight gain of the present study.

The feed cost per kg weight gain was highest in control (Rs.91.76) and lowest in 1.5 % (Rs.89.80) citric acid supplemented group. The decrease of feed cost was 0.82, 2.04, and 2.14 % in 0.5, 1.0 and 1.5 % citric acid supplemented groups respectively when compared to control. Similarly, Lynch *et al.* (2017) observed that the supplementation of sodium butyrate or formic and citric acid could be considered as a cost-effective control

measure to reduce faecal *Salmonella* shedding and improve the average daily weight gain in grower pigs. Further, the decrease in cost of feed per kg weight gain was also observed while the supplementation of feed additives on performance of weaned pigs (Bharathidhasan *et al.*, 2010). The decrease in feed cost of the present study was due to the higher weight gain with lower feed intake in pigs.

The *E.coli* count in feces were significantly ($p < 0.01$) decreased in all citric acid supplemented groups than control during the middle (140th day) and end (205th day) of the experimental periods (Table 3). The decrease in *E.coli* count was from 8.73×10^{11} and 8.78×10^{11} in control to 9.47×10^6 and 9.58×10^6 in 1.5 % citric acid supplemented groups during middle and end of the experimental periods respectively. The pathogenic bacteria like *E.coli* can be inhibited in the acidic condition of gastro intestinal tract (Wolin, 1969). Similarly, Rita Narayanan *et al.* (2008) also reported that the supplementation of 2 % citric acid decreased the *E.coli* count

Table 3. Effect of citric acid supplementation on *Escherichia coli* count of LWY pigs (Mean \pm S.E) (n=6)

Period	Citric acid (%)				
	0	0.5	1.0	1.5	2
Initial (70 th day)	$8.62 \times 10^{11} \pm 0.14$	$8.42 \times 10^{11} \pm 0.27$	$8.42 \times 10^{11} \pm 0.24$	$8.58 \times 10^{11} \pm 0.15$	$8.50 \times 10^{11} \pm 0.18$
Middle (140 th day)	$8.73 \times 10^{11} \pm 0.18^d$	$8.42 \times 10^9 \pm 0.26^c$	$7.58 \times 10^8 \pm 0.20^b$	$9.47 \times 10^6 \pm 0.25^a$	$9.50 \times 10^6 \pm 0.18^a$
End (205 th day)	$8.78 \times 10^{11} \pm 0.17^d$	$8.17 \times 10^9 \pm 0.21^c$	$7.88 \times 10^8 \pm 0.14^b$	$9.58 \times 10^6 \pm 0.11^a$	$9.73 \times 10^6 \pm 0.09^a$

Means bearing different superscript in the same row differ significantly ($p < 0.01$)

significantly ($p < 0.01$) than control in piglets. Feeding organic acids like citric acid to mono gastric animals, especially in pigs are well established and also the organic acids have a negative impact on bacteria and positive impact on growth performance. The reduction in bacterial count could be due to the specific antimicrobial activity of citric acid as it is pH dependent (Dibner and Buttin, 2002).

Further, the reduction of *E.coli* count could be due to the easy penetration of undissociated form of citric acid into the cell membrane of bacteria and dissociate to protons and anions, by which the protons acidify the interior of bacteria and must be extruded to the exterior using energy in the form of ATP (Rita Narayanan *et al.*, 2008). The constant influx of these protons will eventually deplete cellular energy, leaving bacteria no energy for growth. Meanwhile, the dissociated anions accumulate inside bacteria, interrupt the DNA synthesis, which may be responsible for cellular proliferation, impairs protein synthesis and causes depletion of bacteria (Rita Narayanan *et al.*, 2008). This could be the probable reason for decreased *E.coli* count with increased weight gain in the present study. Another possible reason for the improved performance of the pigs in the present study was due to the supplementation of citric acid, lowers the gastric pH and favours the growth of Lactobacilli in the stomach, which possibly inhibit the colonization and proliferation of *E.Coli* by blocking the sites of adhesion or by producing lactic acid and other metabolites lowers the pH, inhibits *E. coli* and other pH sensitive Coliforms (Canibe *et al.*, 2001). It is also known that Lactobacilli could produce hydrogen peroxide which has anti microbial

effects (Reither *et al.*, 1980). The increased weight gain of the current experiment could be due to the effect of citric acid supplementation, may improves protein and energy digestibility's by reducing microbial competition with the host for nutrients and endogenous nitrogen losses and lowering the incidence of sub clinical infections.

CONCLUSION

It was concluded that the citric acid supplementation at minimum inclusion level of 1.5 % improved the weight gain, feed intake, feed efficiency with cost effectiveness and decreased the faecal *E.coli* count in LWY pigs.

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