

Original Research Article

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Effect of Organic Acid Salts as an Alternative to Antibiotic Growth Promoters on the Production Performance of Commercial Broiler Chicken

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ABSTRACT

Keywords

Organic acid, Calcium propionate, Sodium butyrate, Production performance and Alternative to antibiotic growth promoters.

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An experiment was conducted with 240 day old commercial broiler chicks to evaluate the effectiveness of replacing antibiotic growth promoters with organic acid salts on the production performance. Treatment diets were supplemented with lincomycin HCl (4.4 ppm), bacitracin methylene disalicylate (BMD; 50 ppm), each two levels (ppm) of calcium propionate (1000, 2000) and coated sodium butyrate (500, 1000) either alone or in combination (1000+500) with control. The results showed that there was no significant difference in body weight, body weight gain, cumulative feed intake, FCR and livability among the treatment groups. However, the calcium propionate (2000) group had the highest body weight gain with 6.48% more than lower levels (1000). Improved EEF and COP were observed in organic acid treated groups. Calcium propionate and coated sodium butyrate could be safely supplemented as an alternative to antibiotic growth promoters (AGPs) in the commercial broiler diet without affecting the production performance.

Introduction

The use of in fed antibiotics for growth promotion had been arisen with the intensification of livestock farming. Administration of sub-therapeutic level of antibiotics and antimicrobial agents is widely practiced so as to control the infectious agents and to improve the productivity of food animals. Currently, there is a controversy surrounding the use of antibiotic growth promoters (AGPs) for animals destined for meat production, as overuse of any antibiotic over a period of time may lead to resistance of

these bacterial populations to the antibiotic used. Which in-turn affect human health either directly through residues of an antibiotic in meat or indirectly through the selection of antibiotic resistance determinants that may spread to human pathogen.

In 2006, the European Union imposed a complete ban on the use of antibiotics in animal feed as growth promoters. World Health Organization (WHO) along with World Organization for Animal Health (OIE)

encourages the health, agriculture, veterinary sector for reducing the injudicious use of antibiotics as growth promoters and further to decrease the spread of resistant bacteria (Cogliani *et al.*, 2011).

Therefore, other non-therapeutic alternatives such as probiotics, prebiotics, symbiotics, antimicrobial peptides, enzymes, essential oils, eucalyptus oil, organic acids, clay minerals, egg yolk antibodies, rare earth elements, recombinant enzymes and immunostimulants have been introduced as an alternative to the antibiotic growth promoters.

Among the alternatives, organic acids could be considered as the best possible choice for securing the supply of safe food. Acidification increases gastric proteolysis, protein and amino acid digestibility and utilization of minerals and thus improving the performance of the birds (Haque *et al.*, 2009). Organic acids (propionic acid and butyric acid) effectively replace the antibiotics and improve the production performance like body weight gain and FCR (Vijayalakshmi *et al.*, 2015; Adil *et al.*, 2011; Deepa *et al.*, 2016).

The efficiency of the calcium propionate and coated sodium butyrate was not much studied as an alternative to commonly incorporated antibiotic growth promoters such as lincomycin hydrochloride and bacitracin methylene disalicylate (BMD) in the commercial broiler chicken feed in India. Hence, the present study was undertaken to evaluate the response of calcium propionate and coated sodium butyrate at different levels either alone or in combination as an alternative to antibiotic growth promoters such as lincomycin hydrochloride and bacitracin methylene disalicylate (BMD) to assess the production performance and cost of production of the commercial broiler chicken fed with calcium propionate and the salt of butyric acid.

Materials and Methods

A six week biological experiment was conducted in commercial broiler chicken at Poultry Research Station, TANUVAS, MMC, Chennai. The birds were reared in brooder cages for first two weeks; then they were shifted to grower cages till the end of the experiment. The birds were provided with 450 and 929 cm² floor spaces per bird during brooding and growing periods, respectively. The feeding space provided was 3.0 and 7.0 cm per bird during brooding and growing period respectively. The watering space provided in the form of one nipple for 3 birds during brooding and growing period. The chicks were vaccinated against Ranikhet disease [RDVF (day seven), RDV-Lasota (day 28)] and Infectious Bursal Disease (Intermediate Georgia strain; day 14).

The experiment was split into pre-starter (0-14 d), starter (15-28 d) and finisher (29-42 d) periods. For this study, 240 number of unsexed day old chicks (COBB 400) were randomly distributed into eight treatment groups with three replicates each (10 chicks per replicate). They were fed with corn-soybean meal based basal diet (unsupplemented control) or the basal diet with a antibiotic growth promoters (lincomycin; 4.4 ppm and BMD; 50 ppm) or organic acids (OAs) such as calcium propionate (1000 or 2000 ppm) and coated sodium butyrate (500 or 1000 ppm) either alone or in combination (CP 1000 + SB 500) for a period of 42 days.

The body weight of the birds was recorded on day one and every week up to 6 weeks during morning. All treatment groups were provided with *ad libitum* feeding. Feed to gain ratio for each replicate was arrived by dividing average feed consumption by average body weight. Mortality (if any) of birds was recorded during the experimental period of 6

weeks and the livability was calculated. European economic factor was calculated as $[\text{Livability} \times \text{Average body weight}] / (\text{Mean Age (days)} \times \text{FCR}) \times 100$

Cost of Production includes all total input cost/ total kg of chicken sold. Production cost (per kg live weight) was calculated from the chick cost (35 Rs./chick), feed cost, miscellaneous cost (labour cost, medicine and vaccination cost, electricity, etc.; Rs. 5 per kg live weight).

Results and Discussion

Body weight and weight gain

Among treatment groups, there was a non-significant ($P > 0.05$) increase in body weight (Table 1) and weight gain (Table 2) was noticed due to the dietary incorporation of organic acids like calcium propionate (CP) and coated sodium butyrate (SB) during the entire experimental period of six weeks. However, the groups supplemented with organic acid had numerically higher body weight gain than AGPs supplemented and unsupplemented control groups.

Among various treatment groups calcium propionate supplemented at the dose rate of 2000 ppm (T4) showed an increasing trend in the body weight gain from the first to sixth week of age with a difference in magnitude in body weight gain was higher at 6.65 per cent between the groups supplemented with two levels of calcium propionate. The cumulative body weight gain among the groups ranged from the lowest 1865 g in T3 (CP 1000) to the highest 1989 g/ bird in T4 (CP 2000). Dose dependent response was noticed in the groups supplemented with any of the OAs either alone or in combination. The body weight gain obtained in this study with respect to higher level organic acid inclusion agreed with the result of Oruwari *et al.*, (1993) who

observed calcium propionate increased the body weight at the dose rate of 1 g/kg and also agreed with Khosravi *et al.*, (2008) who had incorporated the calcium propionate at the dose rate of 2 g/kg. Likewise, in coated sodium butyrate supplemented treatment, results were in agreement with Hu and Guo (2007), Czerwinski *et al.*, 2012, Brozoska *et al.*, (2013) reiterated that sodium butyrate added to the diets broiler enhanced the body weight gain. The organic acid incorporated in the diet might have a positive influence on the digestibility of in-fed nutrients, improves the gut health and that could be the reason for higher body weight gain in the groups supplemented with OAs and the same can be confirmed with the dose dependant improvement noticed in the body weight gain in those groups.

Feed consumption

Supplementation of AGPs and OAs did not significantly influence the feed consumption (Table 3) among treatment groups. However the unsupplemented control group had lower feed intake than other groups during the overall period. The groups supplemented with higher doses of organic acid had a higher feed intake. The groups supplemented with AGPs forms a second line in the cumulative feed consumption. The cumulative feed consumption (FC) ranged from the lowest 3305 g (BMD) to the highest 3557 g (CP; 2000 ppm; T4) which did not differ due to various dietary treatments though an apparent increase in FC was noticed on the groups supplemented with calcium propionate at 2000 ppm (T4).

The reduction in feed intake in unsupplemented control group might be due to the presence of mild infection in the gastrointestinal tract (GIT) due to pathogenic load which might lead to inflammation that releases proinflammatory cytokines (TNF- α)

into cerebral ventricles potently blocking appetite despite free access to feed (Tracey *et al.*, 1990) and enhancing muscle catabolism (Klasing- cited by khadem *et al.*, 2014). The increased feed intake in AGPs supplemented groups may also explained as the antimicrobial drugs are known to improve the digestibility of nutrients by improving the structure of intestinal flora. This increased digestibility might have enhanced the rate of passage of feed that resulted in increased feed intake (Midtvedt, 1986 and Norin, 1997). Further, sodium butyrate has the ability to increase the gastric emptying and intestinal motility thereby increasing feed intake (Malbert *et al.*, 1994). In addition to that butyrate and propionate induced phasic and tonic contraction in colonic circular muscle (Mitsui *et al.*, 2005; Tazoe *et al.*, 2008) also butyrate has been reported to induce enhancement of colonic motility via the release of 5-HT (Fukumoto *et al.*, 2003).

Feed efficiency

Supplementation of AGPs and OAs did not significantly ($P>0.05$) influence the feed efficiency (Table 4) among treatment groups throughout the period. The mean feed efficiency ranged from better 1.751 (C) to poor 1.817 (T6; SB 1000) among treatments. This result is in agreement with the findings of Shahir *et al.*, (2013); Better feed efficiency was noted in T5 (SB 500) when compared among the groups supplemented with AGPs and OAs. Unsupplemented control groups had a better feed efficiency (1.751) than all other treatment groups, might be due to lower feed intake that may lead to better utilization nutrients at cellular level. In addition, as the entire experimental trail was conducted in the brooder cum grower cages, there may be little chances of getting the pathogenic microbes entering in to the GIT from its own litter which is the ultimate source of infection in the birds maintained in the deep litter system

of management. Among the groups supplemented with organic acid, higher doses of supplementation results in poor feed efficiency than their respective groups supplemented with lower doses. Similar trend was noticed in the groups supplemented with calcium propionate at the dose rate of 2000 ppm (T4) which had a poor feed efficiency than other treatment groups with the value of 1.812. An improvement in the live performance of the birds particularly in higher body weight and body weight gain which was noticed in the groups supplemented with higher level of OAs might be attributed to the higher level of feed consumption in those groups. This higher quantum of feed consumption might be the reason for poor feed efficiency noticed in those groups.

Livability

During the biological experiment of six wks duration, there was a hundred per cent livability was observed among all the treatment groups up to the age of five weeks. During the sixth week of experimental period, the mortality happened in six groups out of eight treatment groups due to heat stroke.

The data on the mean livability of commercial broiler chicken as influenced by supplementation of AGPs and OAs did not significantly affect the livability among the treatment groups. The control groups had lowest livability (76.66 %) whereas lincomycin supplemented groups (T1) had 83.33 % and BMD supplemented groups (T2) had 93.33 % livability. Average livability in AGPs supplemented was 88.33 % whereas OAs supplemented groups was 92.66 %. The groups supplemented with OAs at lower doses (T3 and T5) had a fructiferous livability up to sixth week of age with 100 %. This might be due to the enhanced immune status and suppression of pathogenic bacteria by organic acids.

Table.1 Effect of in fed calcium propionate (CP) and coated sodium butyrate (SB) as growth promoters on the live body weight (g) in commercial broiler chicken (Mean ± SE)

Treatment (ppm)	Age (wks)						
	Day Old	1	2	3	4	5	6
C; Control	48.12 ± 0.71	154.20 ± 2.45	385.46 ± 4.96	771.40 ± 8.38	1229.53 ± 18.00	1689.23 ± 29.94	1964.50± 42.83
T1; Lincomycin HCl - 4.4	47.78 ± 0.75	150.60 ± 3.41	378.66 ± 10.70	748.46 ± 19.49	1176.26 ± 27.63	1656.53 ± 30.74	1965.66 ± 40.09
T2; BMD - 50	46.76 ± 0.74	152.70 ± 2.13	393.23 ± 5.88	769.16 ± 11.86	1214.66 ± 21.95	1681.03 ± 33.40	1937.32 ± 37.97
T3; CP – 1000	47.65 ± 0.72	149.06 ± 3.09	373.76 ± 7.52	732.33 ± 13.65	1161.60 ± 23.81	1639.40 ± 29.44	1913.20 ± 30.30
T4; CP – 2000	47.40 ± 0.77	157.20 ± 3.04	398.20 ± 5.58	772.83 ± 13.28	1238.96 ± 21.74	1747.06 ± 34.89	2037.23 ± 42.83
T5; SB - 500	47.41 ± 0.82	157.76 ± 2.83	385.46 ± 6.63	761.46 ± 10.91	1179.73 ± 18.76	1667.23 ± 30.74	1928.70 ± 35.44
T6; SB - 1000	47.89 ± 0.64	153.10 ± 3.03	397.23 ± 7.07	771.73 ± 11.77	1220.30 ± 21.27	1671.20 ± 36.18	1964.77 ± 41.64
T7; CP - 1000 + SB – 500	47.63 ± 0.77	154.53 ± 2.28	387.26 ± 7.38	768.66 ± 14.65	1227.46 ± 22.62	1685.86 ± 30.69	1943.03 ± 31.77
F value	0.300	1.119	1.440	1.170	1.725	0.979	1.010
Significance	NS	NS	NS	NS	NS	NS	NS

Means bearing different superscripts within the same column differ significantly; **Highly significant (P<0.01); * Significant (P<0.05); NS – Non significant (P> 0.05); Dose of coated sodium butyrate was calculated based on the actual quantum of butyric acid present in it.

Table.2 Effect of in fed calcium propionate (CP) and coated sodium butyrate (SB) as growth promoters on the cumulative body weight gain (g) in commercial broiler chicken (Mean ± SE)

Treatment (ppm)	Experimental period (wks)					
	1	2	3	4	5	6
C; Control	106.07 ± 2.30	337.34 ± 4.90	723.27 ± 8.46	1181.40 ± 18.07	1641.10 ± 30.13	1915.83 ± 43.15
T1; Lincomycin HCl - 4.4	102.82 ± 3.39	330.88 ± 10.57	700.68 ± 19.54	1128.48 ± 27.55	1608.75 ± 30.71	1917.73 ± 39.97
T2; BMD – 50	105.94 ± 2.13	346.47 ± 5.78	722.40 ± 11.77	1167.90 ± 21.94	1634.27 ± 33.33	1890.66 ± 37.87
T3; CP – 1000	101.41 ± 3.02	326.11 ± 7.37	684.68 ± 13.49	1113.95 ± 23.63	1591.75 ± 29.37	1865.55 ± 30.20
T4; CP – 2000	109.80 ± 2.84	350.80 ± 5.43	725.43 ± 13.01	1191.56 ± 21.46	1699.66 ± 34.56	1989.33 ± 42.43
T5; SB – 500	110.35 ± 2.45	338.05 ± 6.23	714.05 ± 10.54	1132.32 ± 18.45	1619.82 ± 30.47	1881.28 ± 35.12
T6; SB – 1000	105.20 ± 2.85	349.34 ± 6.83	723.84 ± 11.64	1172.40 ± 21.19	1623.30 ± 36.26	1917.02 ± 41.63
T7; CP - 1000 + SB – 500	106.90 ± 2.16	339.63 ± 7.23	721.03 ± 14.47	1179.83 ± 22.49	1638.23 ± 30.57	1895.55 ± 31.66
F value	1.310	1.555	1.199	1.744	0.988	1.005
Significance	NS	NS	NS	NS	NS	NS

Means bearing different superscripts within the same column differ significantly; **Highly significant (P<0.01); * Significant (P<0.05); NS – Non significant (P> 0.05).

Table.3 Effect of in fed calcium propionate (CP) and coated sodium butyrate (SB) as growth promoters on cumulative feed consumption (g) in commercial broiler chicken (Mean ± SE)

Treatment (ppm)	Experimental period (wks)					
	1	2	3	4	5	6
C; Control	135.30± 2.55	470.30± 23.05	1040.23± 29.69	1796.43± 50.08	2665.93 ± 67.47	3226.93± 141.14
T1; Lincomycin HCl - 4.4	138.60± 1.77	474.93± 21.08	1033.06± 41.71	1785.10± 57.95	2668.66 ± 65.16	3325.15± 58.08
T2; BMD – 50	136.93± 2.63	498.13± 5.82	1068.93± 17.98	1813.93± 45.71	2699.53 ± 57.91	3305.51± 83.77
T3; CP – 1000	137.70± 5.54	476.70± 15.85	1011.76± 21.66	1750.46± 39.83	2692.36 ± 49.69	3350.06± 67.99
T4; CP – 2000	148.93± 5.63	527.70± 2.62	1096.93± 19.07	1863.26± 8.65	2810.13 ± 22.98	3557.05± 40.95
T5; SB – 500	142.76± 1.04	489.80± 9.52	1052.56± 15.09	1789.73± 18.08	2665.70 ± 44.96	3332.43± 51.89
T6; SB – 1000	144.56± 0.82	515.63± 5.87	1075.66± 14.48	1841.73± 29.64	2743.90 ± 31.08	3443.59± 42.06
T7; CP - 1000 + SB – 500	142.20± 4.59	488.70± 7.23	1063.70± 19.73	1818.90± 21.82	2741.40 ± 56.51	3351.69± 71.20
F value	1.633	2.274	1.248	0.874	0.974	1.699
Significance	NS	NS	NS	NS	NS	NS

Means bearing different superscripts within the same column differ significantly; **Highly significant (P<0.01); * Significant (P<0.05); NS – Non significant (P> 0.05).

Table.4 Effect of in fed calcium propionate (CP) and coated sodium butyrate (SB) as growth promoters on feed efficiency in commercial broiler chicken (Mean ± SE)

Treatment (ppm)	Experimental period (wks)					
	1	2	3	4	5	6
C; Control	1.275 ± 0.02	1.393± 0.04	1.438 ± 0.03	1.520 ± 0.03	1.624 ± 0.02	1.751 ± 0.34
T1; Lincomycin HCl - 4.4	1.355 ± 0.06	1.436± 0.02	1.474 ± 0.01	1.582 ± 0.02	1.658 ± 0.01	1.798 ± 0.00
T2; BMD – 50	1.295 ± 0.05	1.439± 0.02	1.480 ± 0.02	1.554 ± 0.04	1.652 ± 0.03	1.755 ± 0.04
T3; CP – 1000	1.362 ± 0.07	1.461± 0.03	1.477 ± 0.01	1.571 ± 0.02	1.691 ± 0.00	1.795 ± 0.01
T4; CP – 2000	1.361 ± 0.04	1.505± 0.02	1.515 ± 0.06	1.567 ± 0.05	1.656 ± 0.05	1.812 ± 0.04
T5; SB – 500	1.295 ± 0.02	1.448± 0.01	1.474 ± 0.01	1.580 ± 0.00	1.645 ± 0.00	1.771 ± 0.01
T6; SB – 1000	1.377 ± 0.04	1.476± 0.01	1.486 ± 0.02	1.572 ± 0.02	1.691 ± 0.03	1.817 ± 0.03
T7; CP - 1000 + SB – 500	1.333 ± 0.05	1.439± 0.00	1.475 ± 0.00	1.542 ± 0.02	1.673 ± 0.04	1.797 ± 0.02
F value	0.524	1.569	0.495	0.449	0.537	0.618
Significance	NS	NS	NS	NS	NS	NS

Means bearing different superscripts within the same column differ significantly; **Highly significant (P<0.01); * Significant (P<0.05); NS – Non significant (P> 0.05).

Table.5 Effect of in fed calcium propionate (CP) and coated sodium butyrate (SB) as growth promoters on the production cost, European Economic Factor and Average daily gain (g) in commercial broiler chicken

Treatment (ppm)	Feed cost (Rs./kg)			Production cost (Rs./kg live wt)	European Economic Factor (EEF)	Avg. daily gain (g)
	Pre-Broiler starter	Broiler starter	Broiler finisher			
C; Control	25.75	26.39	26.97	74.73	205	46.76
T1; Lincomycin HCl - 4.4	25.79	26.43	27.02	74.24	217	46.79
T2; BMD - 50	25.92	26.56	27.14	71.28	245	46.12
T3; CP – 1000	26.50	27.14	27.73	72.35	254	45.55
T4; CP – 2000	27.26	27.90	28.48	75.74	232	48.5
T5; SB - 500	26.59	27.23	27.81	71.68	259	45.93
T6; SB - 1000	27.43	28.07	28.65	75.39	240	46.79
T7; CP - 1000 + SB – 500	27.35	27.98	28.57	77.23	215	46.26

EEF = [Livability x Average body weight / Mean Age (days) x FCR] x 100; Cost of Production=Total of all input cost/ Total Kg of Chicken sold; Production cost (per kg live weight) was calculated from the chick cost (35 Rs./chick), feed cost, miscellaneous cost (Labour cost, medicine and vaccination cost, electricity, etc.; Rs. 5 per kg live weight).

Moreover, organic acid (acetic acid) supplementation increased the water consumption even in heat stressed birds that resulted in enhanced performance and immune response than control birds (Hassan *et al.*, 2009). Besides, butyrate induced the cell proliferation; migration and differentiation require BDNF- tyrosine kinase B signaling and may contribute to long-term beneficial effects of butyrate after ischemic injury this may resulted in reduced mortality in organic acid supplemented groups (Kim *et al.*, 2009).

Cost of production higher in organic acid combination groups. And Higher European Economic Factor noticed in butyric acid supplemented groups. By considering the both parameter T5 (Butyric acid – 500) group was superior in performance.

Cost of production and European Economic Factor

The data pertaining to cost of production/ kg of live weight (Table 5) indicated that higher cost of production noted in the dietary treatment groups supplemented with organic acids in combination (T7) that had Rs.77.23 which is higher than all other treatment groups including control. Treatments like T1 (linco), T2 (BMD), T3 (CP 1000) and T5 (SB 500) bringing down the COP by Rs. 0.49, 3.45, 2.38 and 3.05, respectively when compared to control group; whereas T4 (CP 2000), T6 (SB 1000) and T7 (CP 1000 + SB 500) had increased the COP by Rs. 1.01, Rs. 0.66 and Rs. 2.55, respectively. It was observed that the groups supplemented at lower doses of organic acid (T3 and T5) showed an increased EEF than their respective higher doses (T4 and T6) supplemented group. The group T5 (SB 500) had 54 points higher EEF than Control; 42 points higher than T1 (lincomycin); 14 points higher than T2 (BMD); 5 points higher than T3 (CP 1000); 27 points higher than T4 (CP 2000); 19 points higher than T6 (SB 1000); 44 points higher than T7 (CP 1000 + SB 500). From these findings, it was inferred that the groups supplemented with sodium butyrate (T5) found to be superlative

than other groups since mortality is zero per cent, higher EEF and reduced feed consumption than other organic acid supplemented groups.

Based on the overall performance of broilers, salts of organic acids (OAs) such as calcium propionate and coated sodium butyrate could be safely supplemented as an alternative to antibiotic growth promoters (AGPs) in the commercial broiler diet without affecting the production performance such as body weight gain, feed consumption, feed efficiency and livability. Among these two organic acid salts studied in this experiment, at various concentrations either alone or in combination, supplementation of coated sodium butyrate at 500ppm could be considered for achieving the overall performance with better cost of production. Salts of organic acids (OAs) could be safely supplemented as an alternative to antibiotic growth promoters (AGPs) in the commercial broiler diet to lower the risk of residues in the meat and to avoid the antibiotic resistance (if any) to the consumers.

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