EFFECT OF ORGANIC ACID SALTS SUPPLEMENTATION ON THE PERFORMANCE OF BROILERS

THESIS

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by

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1. INTRODUCTION

High levels of production and efficient feed conversion are the need of present day modern poultry industry, which to a certain extent could be achieved by the use of specific feed additives. Therefore, poultry sector is continuously searching for new feed additives in order to improve the feed efficiency and chicken health.

Antibiotic feed additives as growth promoters have long been supplemented to poultry feed to stabilize the intestinal microbial flora, improve the general performances and prevent some specific intestinal pathology (Hassan et al., 2010). However, due to the emergence of microbes resistant to antibiotics which are used to treat human and animal infections, the European Commission (EC) decided to phase out, and ultimately ban (1 January, 2006), the marketing and use of antibiotics as growth promoters in feed (EC Regulation No. 1831/2003). That’s why alternative materials to antibiotics are researched.

In developing countries, consumer pressure is pushing the poultry industry to rear poultry without antibiotics (Castanon, 2007). Antibiotics removal has led to poultry performance problems, feed conversion increases and a rise in the incidence of certain animal diseases, such as (subclinical) necrotic enteritis (Dibner and Richards, 2005). Such a situation has compelled the researcher’s to explore the utility of other non-therapeutic alternatives like organic acids, enzymes, probiotics, prebiotics, herbs, essential oils and immunostimulants as feed additives in poultry production, among these compounds, organic acids are promising alternatives (Hyden, 2000).

Organic acid treatments composed of individual acids and blends of several acids have been found to perform antimicrobial activities similar to those of antibiotics (Wang et al., 2009). The European Union allowed the use of organic acids and their salts in poultry production because these are generally considered safe (Adil et al., 2010).

Organic acids are weak acids and are only partly dissociated. Most organic acids with antimicrobial activity have a pKa (the pH at which the
acid is half dissociated) between 3 and 5. A wide range of organic acids with variable physical and chemical properties exists, of which many can be used as drinking water supplements or as feed additives (acidifiers). Many are available as sodium, potassium or calcium salts (and/or partially esterified). The advantage of salts over acids is that they are generally odourless and easy to handle in the feed manufacturing process owing to their solid and less volatile form. They are also less corrosive and may be more soluble in water (Huyghebaert et al., 2011).

The addition of organic acids in diet can have a beneficial effect on the performance of poultry by decreasing intestinal total bacterial count in caeca (Hamed and Hassan, 2013). Organic acid supplementation can significantly increase the villus width, height and area of the duodenum, jejunum and ileum of broiler birds (Rodríguez-Lecompte et al., 2012). Some workers have also suggested that the improvement in bird immunity could be related to the inhibitory effects of organic acids on gut system pathogens (Ghazalah et al., 2011). Similarly, organic acid mixtures were found to be more efficient than the Enramycin, an antibiotic growth promoter (Hassan et al., 2010). Therefore the use of organic acids has been reported to protect the young chicks by competitive exclusion (Mansoub et al., 2011), enhancement of growth, nutrient utilization and feed conversion efficiency (Luckstadt and Mellor, 2011).

Previous studies reported that organic acids and their salts have shown variable effects on performance and carcass quality parameters in broilers. These discrepancies would be related to the source, the amount of organic acids used, location, environmental condition and the composition of the diets (Gama et al., 2000).

Therefore, present study is planned with the following objectives:

1. To determine the effect of organic acid salts supplementation on performance, nutrient utilization and carcass traits of broilers.
2. To study the effect of organic acid salts supplementation on immune response and economics of broiler production.
2. REVIEW OF LITERATURE

The present study was planned to study the effect of organic acid salts supplementation on the performance of broilers. The literature has been reviewed on following parameters:-

2.1 Supplementation of organic acid in broiler chickens

(A) Growth parameters

Panda (2009) conducted an experiment to study the effect of graded levels of butyric acid (butyrate) on performance in young broiler chickens. The results showed that 0.4% butyrate in the diet was similar to antibiotic in maintaining body weight gain and superior for feed conversion ratio.

Hudha et al. (2010) studied the effect of acetic acid on growth performance in broilers. The results revealed that body weight and feed intake were higher (p<0.05) on 0.15% acetic acid level than that on control, 0.05 and 0.10% acetic acid. They concluded that supplementation of acetic acid in drinking water might improve growth and feed conversion of broilers.

Adil et al. (2011) conducted a trial to determine the effect of dietary supplementation of organic acids on the performance of broiler chickens. The birds in the control (T1) group were fed the basal diet whereas in other treatment groups basal diet was supplemented with 2% butyric acid (T2), 3% butyric acid (T4), 2% fumaric acid (T4), 3% fumaric acid (T5), 2% lactic acid (T6), and 3% lactic acid (T7). The results indicated that the organic acid supplementation, irrespective of type and level of acid used, had a beneficial effect on the performance of broiler chickens.

Ghazalah et al. (2011) conducted a study to compare the effects of different types and levels of organic acids Formic (0.25, 0.5 and 1.0%), Fumaric (0.5, 1.0 and 1.5%), Acetic (0.25, 0.50 and 0.75%) and Citric Acids (1, 2 and 3%) in broiler diets. They concluded that 0.5% of either formic, or fumaric, 0.75% acetic or 2% citric acids could be used safely in broiler diets to improve their performance.
Aghazadeh and Tahayazdi (2012) evaluate the effects of butyric acid and wheat on the performance of broiler chickens. They concluded that dietary supplementation with butyric acid had no effect on average weight gain (AWG) or feed conversion ratio (FCR) in the starter, grower/finisher.

Hedayati et al. (2013) conducted a study to investigate the effects of the dietary supplementation of an acidifier on performance of broilers. Results showed that among weekly body weight, feed intake and FCR, there was a significant (P<0.05) improvement, however, the maximum difference were noticed in the level of 0.1%, followed by 0.05% and 0.025% levels. They concluded that dietary acidifier agent increased the performance of broiler chickens.

Sohail et al. (2015) conducted an experiment to study the effect of benzoic, acetic and formic acid supplementation on growth performance of broilers. They concluded that addition of organic acids (benzoic, acetic and formic) is helpful to improve weight gain, feed intake and feed conversion ratio of the birds.

Al-Sultan et al. (2016) studied comparative effects of using prebiotic, probiotic, synbiotic and acidifier on growth performance of broiler chicks. They concluded that use of synbiotic followed by probiotic is preferable as efficient growth and health promoters for broilers in comparison with prebiotic and organic acids.

Rout et al. (2016) evaluated the influence of probiotic and acidifier supplementation on growth performance in broilers. They concluded that probiotics and acidifiers supplementation either singly or in combination improved the growth performance or feed efficiency in commercial broilers, however, the combination of probiotics and acidifier gave the best results.

Ndelekwute and Enyenihi (2017) conducted an experiment to determine the effect of lime juice (Citrus aurentifolia) on growth performance of broilers. Results showed that at the starter phase, the lime juice at 2.50% significantly (P<0.05) improved feed intake, final live weight and weight gain. At the finisher phase, final live weight was significantly (P<0.05) improved by 2.0 and 2.50%.
(B)  **Nutrient utilization**

Ghazalah *et al.* (2011) conducted a study to compare the effects of different types and levels of organic acids (Formic (0.25, 0.5 and 1.0%), Fumaric (0.5, 1.0 and 1.5%), Acetic (0.25, 0.50 and 0.75%) and Citric Acids (1, 2 and 3%) in broiler diets. Results revealed that tested organic acids improved both ME and nutrients digestibility (CP, EE and NFE) of the experimental diets compared to the control.

Hassan *et al.* (2015) conducted an experiment to study nutrients digestibility of broiler chickens fed corn-soybean meal diets supplemented with a commercial phytogenic product, mixture of organic acids and a combination of both. The results showed that supplementation of organic acids mixture improved the digestibility coefficients (p<0.01) of DM, OM, CP, CF and NFE compared to the un-supplemented diet.

Ndelekwute *et al.* (2016) conducted an experiment to determine the effect of organic acids (acetic, butyric, citric and formic acids) on growth and nutrient digestibility of broilers. Crude protein and ether extracts digestibility were improved by the supplementation of all the tested organic acids (P<0.05). They concluded that 0.25% formic acid could be added to broiler diets.

Ndelekwute and Enyenihi (2017) conducted an experiment to determine the effect of lime juice (*Citrus aurentifolia*) on nutrient digestibility of broilers. Results showed that the supplementation of lime juice (1.5%) improved digestibility of protein, fat and oil.

(C)  **Humoral immune response**

Sohail *et al.* (2015) conducted an experiment to study the effect of benzoic, acetic and formic acid supplementation on immune response of broilers. The results revealed that maximum significant value of IBD antibody titer (96.00GMT) was found in treatment ‘C’ (formic acid) and minimum (41.67GMT) in treatment ‘A’ (benzoic acid). However, the best result against ND antibody titer (104.67GMT) was found in treatment ‘D’ (control group).
Al-Sultan et al. (2016) studied comparative effects of using prebiotic, probiotic, synbiotic and acidifier on immune response of broiler chicks. They concluded that synbiotic followed by probiotic supplemented groups revealed the highest antibody response to Newcastle disease vaccine (NDV) in comparison with prebiotic and organic acids.

(D) Intestinal microbial population

Hassan et al. (2010) studied the effect of using two commercial mixtures of organic acids to substitute antibiotic growth promoter (Eneramycin) on intestinal microflora of broilers. The results showed that organic acid mixtures are more efficient than antibiotic growth promoter (Enramycin) in decreasing intestinal *Escherichia coli* and *Salmonella* spp., and could be successfully used to substitute antibiotic growth promoters in broiler diets.

Adil et al. (2011) conducted an experiment to evaluate the efficiency of organic acid salts supplementation on caecal bacterial count in broiler chicken. Birds in the control (T1) group were fed basal diet where as birds in other treatment groups were fed basal diet supplemented with 2% butyric acid (T2), 3% butyric acid (T4), 2% fumaric acid (T4), 3% fumaric acid (T5), 2% lactic acid (T6) and 3% lactic acid (T7). They concluded that addition of organic acids to the diet of broiler chickens decreased (P<0.05) the caecal viable and coliform counts compared to the unsupplemented group.

Ghazalah et al. (2011) conducted a study to compare the effects of different types and levels of organic acids including Formic (0.25, 0.5 and 1.0% FA), Fumaric (0.5, 1.0 and 1.5% FUA), Acetic (0.25, 0.50 and 0.75% AC) and Citric Acids (1, 2 and 3% CA) on broilers ceacal bacterial count. Feeding dietary FA and FUA led to sharp reduction in ceacal content of lactobacilli bacteria, but number of coliforms bacteria and anaerobes was slightly increased. Feeding 0.75% AC and 2%CA increased *Lactobacillus* and coliform counts.
Mohamed et al. (2014) designed an experiment to evaluate the effects of using organic acids as an alternative to antibiotic growth promoter on intestinal microbial population of broiler chicks. The results showed that addition of organic acids could be successfully used as an alternative to antibiotic growth promoters in broiler diets.

Al-Sultan et al. (2016) studied comparative effects of using prebiotic, probiotic, synbiotic and acidifier on intestinal microbial ecology of broiler chicks. They found that synbiotic followed by probiotic supplementation significantly improved intestinal microbial ecology than prebiotic, organic acids and control group.

(E) Carcass Characteristics

Panda et al. (2009) conducted an experiment to study the effect of graded levels of butyric acid (butyrate) on carcass characteristics in young broiler chickens. Four other experimental diets were formulated to contain 0.05% antibiotic (furazolidone) or 0.2, 0.4 and 0.6% butyric acid. They concluded that 0.4% butyric acid supplementation maintained carcass quality in broiler chickens.

Dizaji et al. (2012) conducted a trial to investigate the effects of dietary supplementations of Prebiotic, Probiotic, synbiotic and acidifier on organs weight of broiler chickens. The weight of proventriculus, Gizzard, liver, and Bursa did not differ significantly (P>0.05) between groups. Additionally, the weight of Spleen increased significantly (P<0.05) in probiotic group compared with control group.

(F) Economics of feeding

Hudha et al. (2010) studied the effect of acetic acid on economics of broiler production. The results revealed that feed cost/broiler significantly increased (P<0.01) with increasing acetic acid levels. Increased cost for producing each kg broiler on 0.15% acetic acid than that on other levels perhaps indicates that acetic acid level should be below 0.15% to optimize economic performance.
Kamel and Mohamed (2016) conducted a study to evaluate the effect of different feed additives (Probiotics, Prebiotic, Synbiotic, Organic acids and Enzymes) on productive and economic efficiency of broiler breeds. The value of total return was the highest for organic acid groups for both Cobb and Ross breed (L.E 27.72 and 27.41, respectively) and for Synbiotic groups (L.E 27.0 and 27.26 respectively), while the lowest value was found for the enzyme group of Cobb breed (L.E 25.16). The value of net profit was the highest for synbiotic group of Ross breed and organic acid group of Cobb breed (L.E 5.35 and 4.95 /chicken), respectively.

Rout et al. (2016) evaluated the influence of probiotic and acidifier supplementation on economics of feeding in broilers. The chicks in the groups T2, T3 and T4, were fed with probiotics @ 50 g, acidifier @ 2 kg and probiotics @ 50 g + acidifier @ 2 kg/tonne of feed, respectively. Net return per kg live weight gain was the highest for group T4 followed by T3, T2 and control group, however, the differences among the groups were not significant (P>0.05).

2.2 Supplementation of probiotic, synbiotic and antibiotic growth promoter (AGP) in broiler chickens

(A) Growth parameters

Blake et al. (2006) conducted a study to compare efficacy of a commercial mannan oligosaccharide and Bacitracin Methylene Disalycilate (BMD). Results indicate highly significant (P<0.0009) improvements in BW with MOS and BMD over control at 14 day. Feed consumption and FCR was greatest for BM (P<0.026 over control) intermediate for MOS and lowest for control. The combination effects indicate that cumulative improvements in performance of broilers.

Paul et al. (2007) conducted an experiment to determine the influence of combination of organic acid salts as substitute for antibiotics on the performance of broiler chickens. No significant difference (P>0.05) between antibiotic and the acidifier supplemented groups was found in live weight or live weight gain (LWG). However, cumulative feed intake was significantly higher (P<0.05) in the antibiotic supplemented group compared with the acidifier supplemented groups.
Bozkurt et al. (2009) conducted experiment to observe the effect of prebiotic, mannan oligosaccharide and antibiotic growth promoter on the performance of broilers. The addition of all experimental additives to the diet resulted in significantly higher (P<0.05) body weights and feed conversion ratio than the control group. The results showed that AGP, MOS and Prebiotic supplementation to a diet provided significant (P<0.05) advantages on broiler growth performance.

Armut and Filazi (2012) determined the effects of probiotics, oligosaccharides, organic acids, and avilamycin used either alone or in combination to improve productivity. They conclude that these growth promoting products have positive effects that act synergistically, hence, leading to improved growth and feed conversion. Probiotics, oligosaccharides, and organic acid mixtures can be used as good alternative feed supplements to antibiotics.

Sohail et al. (2012) evaluated the effects of supplementing mannan-oligosaccharides (MOS) and probiotic mixture (PM) on growth performance, in broilers kept under chronic heat stress. The results showed that supplementation of the MOS and the PM can partially lessen these changes.

Sarangi et al. (2016) aim was to investigate the effects of dietary supplemtations of prebiotic, probiotic, and synbiotic on growth performance of broiler chickens. The highest body weight observed in synbiotic group, which was non-significantly (P>0.05) higher than the control group. Total feed intake and feed conversion ratio did not show any significant (P>0.05) difference in broiler chickens fed on prebiotic, probiotic, and synbiotic groups as compared with control group.

(B) Nutrient utilization

Mountzouris et al. (2010) conducted an experiment to determine the effect of inclusion of 5-bacterial species as probiotic on nutrient utilization of broilers. They concluded that probiotic inclusion level had a significant (P<0.05) effect on nutrient utilization of broilers.
Houshmand et al. (2011) conducted an experiment to determine the effects of different feed additives on nutrient retention of broilers. Dietary inclusion of additives had no significant effects on AME. Prebiotic and organic acid significantly (P<0.05) improved protein digestibility. The recommended-energy diets significantly (P<0.05) increased AME and protein digestibility.

(C) Humoral immune response

Ghosh et al. (2012) compared the effects of an antibiotic growth promoter (AGP), yeast (Saccharomyces cerevisiae) and yeast cell wall (YCW) on humoral immune responses in Ross 308 broilers. They concluded that the yeast and the yeast cell wall may have effects identical to BMD on humoral immune response of broilers.

Ghahri et al. (2013) conducted a feeding trial to investigate the effects of dietary supplementation of antibiotic, probiotic, prebiotic and synbiotic on broilers immune response. Synbiotic treated animals showed increase (p<0.05) in antibody titre against NDV compared to those of the control groups.

Razek and Tony (2013) investigated the effects of a mixture of synbiotic and feed enzymes on immune status of broiler chickens. They concluded that, using mixtures of synbiotics and digestive enzymes act synergistically as feed additives, reduce stress and enhance immune status of broilers.

Al-Sultan et al. (2016) investigated the effects of dietary prebiotic, probiotic, synbiotic and organic acid salt supplementation on immune response of broilers. Synbiotic followed by probiotic supplemented groups revealed the highest antibody response to Newcastle disease vaccine (NDV) in comparison with prebiotic and organic acids.

(D) Intestinal microbial population

Singh et al. (2008) designed a study to evaluate the effects of Bacitracin Methylene Disalicylate @150 g and 200 g/MT and Virginiamycin 500g/MT on bacterial population (Salmonella and E. coli). The sample of excreta collected during II, IV and VI week of experiment did not show any incidences of Salmonella in any treatment groups, however, the excreta of six week in all the treatment groups showed the incidences of E. coli.
Abdel-Raheem and Abd-Allah (2012) investigated the effects of dietary supplementation of prebiotic (MOS), Probiotic (Saccharomyces cerevisiae) and their combination (synbiotic) on intestinal microflora of broilers. The results show that concentrations of bacteria belonging to Lactobacillus spp. in the duodenum and jejunum digesta were significantly ($P<0.05$) higher in prebiotic supplemented broilers compared with the control and synbiotic treatments.

Al-Sultan et al. (2016) investigated the effects of dietary prebiotic, probiotic, synbiotic and organic acid salt supplementation on intestinal microflora of broilers. The microbiology of birds showed significant ($P<0.01$) improvement with dietary synbiotic followed by probiotic, prebiotic and organic acid.

(E) Carcass Characteristics

Toghyani et al. (2011) designed to investigate the impact of probiotic and prebiotic as growth promoter agents compared to antibiotic on carcass traits of broiler chicks. Results showed that carcass yield and relative organ weights were not influenced by dietary treatments, but inclusion of prebiotic and antibiotic in the diet significantly ($P>0.05$) reduced the weight of abdominal fat pad of birds in comparison to control birds.

Abdel-Raheem and Abd-Allah (2012) investigated the effects of dietary supplementation of prebiotic (MOS), probiotic (Saccharomyces cerevisiae) and their combination (synbiotic) on some carcass traits in broilers. The final carcass yield percentage and organ weights were significantly ($P<0.05$) increased in probiotic and synbiotic supplemented broilers in comparison with the control and prebiotic groups.

Sarangi et al. (2016) aim was to investigate the effects of dietary supplementations of prebiotic, probiotic, and synbiotic on carcass characteristics of broiler chickens. They found no significant ($P>0.05$) difference in the carcass traits with respect to dressing percentage, carcass percentage, and organs weight percentage in Cobb broilers.
(F) Economics of feeding

Hosamani et al. (2010) designed a trial on broilers to study the influence of supplementing feed additives either antibiotic, probiotic or their combination on relative economics. Relative economics revealed higher returns in probiotic group followed by antibiotic supplemented group and least in probiotic plus antibiotic combination group.

Saiyed et al. (2015) conducted an experiment to study the inclusion of probiotic, prebiotic and its combination in broiler diet and their effect on economics of commercial broilers. They concluded that synbiotic has a beneficial effect over probiotic and prebiotic when used alone.

Rout et al. (2016) conducted an experiment to evaluate the influence of probiotics and acidifier supplementation on economics of broiler feeding. Net return per kg live weight gain was the highest for probiotics followed by acidifiers and control group, however, the differences among the groups were not significant (P>0.05).
3. MATERIAL AND METHODS

3.1 Materials

Location and Place of work

The proposed experiment was conducted in the department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Jabalpur (M.P.). The comprehensive programme of work was as follows:-

Experiment

The study was planned to see effect of organic acid salts supplementation on the performance of broilers.

Housing

The experimental chicks were reared in the battery brooder house. The battery brooders were cleaned, washed and disinfected by blow lamping and complete house was fumigated using formaldehyde and potassium permanganate four days prior to start of the experiment. Feeders and waterer were carefully cleaned with detergent. Artificial heat was provided to chicks during early period of growth using electric bulbs. In addition, room heaters were also used to maintain the room temperature as the experiment was conducted in spring season.

Duration of Experiment

Experiment was conducted for a period of six weeks. It was started on 29\textsuperscript{th} January 2017 and terminated on 11\textsuperscript{th} March 2017.

Experimental diet

Feed

The feed ingredients used in the experiment were maize, soybean meal and oil. The mineral supplements used in diets were DCP, LSP, choline chloride, liver tonic, toxin binder, sodium chloride, coccidiostat, betaine, trace minerals and vitamins (A, D\textsubscript{3}, E, C, K and B complex) premix. The ingredients were procured in one lot for whole experiment. They were grinded and screened properly to get uniform particle size for formulation of diets. The proximate composition of feed ingredients used in the experiment is presented in Table 1.
Table 01: Proximate composition of feed ingredients (% DM basis)

<table>
<thead>
<tr>
<th>Constituents (%)</th>
<th>Maize</th>
<th>Soybean meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>11.82</td>
<td>12.73</td>
</tr>
<tr>
<td>Crude protein*</td>
<td>8.50</td>
<td>44.50</td>
</tr>
<tr>
<td>Ether extract*</td>
<td>3.20</td>
<td>1.34</td>
</tr>
<tr>
<td>Crude fibre*</td>
<td>1.90</td>
<td>7.50</td>
</tr>
<tr>
<td>NFE</td>
<td>69.46</td>
<td>27.11</td>
</tr>
<tr>
<td>Ash*</td>
<td>5.12</td>
<td>6.82</td>
</tr>
<tr>
<td>ME (Kcal/kg)</td>
<td>3340</td>
<td>2250</td>
</tr>
</tbody>
</table>

*Value analyzed in the laboratory

**Dietary treatments**

There were 14 dietary treatments. All the diets (Pre-starter, Starter and Finisher) were prepared as per BIS (2007) feeding standard for poultry.

- **T1** = Standard broiler diet as per BIS (2007) feeding standard (Pre starter: 0-7 days, 23%CP and 3000kcal ME/kg diet; Starter: 8-21 days, 22%CP and 3100kcal ME/kg diet and Finisher: 22-42 days, 20%CP and 3200kcal ME/kg diet)
- **T2** = T1 + 2% Sodium acetate
- **T3** = T1 + 2% Calcium sorbate
- **T4** = T1 + 2% Calcium propionate
- **T5** = T1 + 2% Sodium butyrate
- **T6** = T1 + 2% Sodium lactate
- **T7** = T1 + 3% Sodium Acetate
- **T8** = T1 + 3% Calcium sorbate
- **T9** = T1 + 3% Calcium propionate
- **T10** = T1 + 3% Sodium butyrate
- **T11** = T1 + 3% Sodium lactate
- **T12** = T1 + Probiotic (*Saccharomyces boulardii*, 10⁸CFU/kg) @500g/tonne of feed
- **T13** = T1 + Probiotic @500g/tonne of feed + Prebiotic (MOS) @1kg/tonne of feed
- **T14** = T1 + AGP (Bacitracin Methylene Disalicylate) @500g/tonne of feed

All diets for each period were prepared with the same batch of ingredients and all diets within a period had the same composition.
Computation of Ration

The feed ingredients were procured from the market and analyzed for proximate composition before formulation of diet. The experimental diets were formulated as per BIS (2007) specifications. All the diets were containing 23%, 22% and 20% CP and 3000, 3100 and 3200 kcal ME per kg diet for pre starter, starter and finisher, respectively and were supplemented with organic acid salts (Sodium acetate, Calcium sorbate, Calcium propionate, Sodium butyrate, Sodium lactate at 2% and 3% level) and Probiotic, Prebiotic and Antibiotic Growth Promoter (AGP).

The analyzed protein and ME calculated values of feed ingredients were used for computation of rations. Ingredients composition of experimental broiler diets used in the study is given in Table 2.

Experimental birds

A total of 280 day old broiler chicks duly vaccinated against Marek’s disease were purchased from reputed Hatchery at Jabalpur. Out of which, 252 chicks were selected for experiment. During the experiment, all the chicks were vaccinated against Ranikhet disease (F1 strain) on 7th day. Then on 14th day chicks were vaccinated against IBD. Thereafter, on 28th day, all the chicks were immunized by giving booster dose against Ranikhet disease (Lasota strain) through intra-occular route.

Experimental design

The design of the experiment was completely randomized design. All the day old Cobb broilers chicks were individually weighed at the start of experiment. Extremely light or heavy chicks were rejected and only 252 chicks from remaining population were randomly assigned to various groups so that average weight of the chicks in any two groups did not differ significantly. Overall, there were fourteen dietary treatments. Each treatment consisted of three replicates of six broiler chicks each.
Table 02: Ingredient composition of broiler experimental diets

<table>
<thead>
<tr>
<th>Feed Ingredients</th>
<th>Experimental Diets (%)</th>
<th>Pre starter (0-7 days)</th>
<th>Starter (8-21 days)</th>
<th>Finisher (22-42 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td></td>
<td>49.68</td>
<td>50.99</td>
<td>54.85</td>
</tr>
<tr>
<td>Soya bean Cake</td>
<td></td>
<td>41.50</td>
<td>38.90</td>
<td>34.50</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>4.40</td>
<td>5.70</td>
<td>6.71</td>
</tr>
<tr>
<td>LSP</td>
<td></td>
<td>1.30</td>
<td>1.25</td>
<td>1.20</td>
</tr>
<tr>
<td>DCP</td>
<td></td>
<td>1.75</td>
<td>1.75</td>
<td>1.70</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td></td>
<td>0.30</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>L-Lysine</td>
<td></td>
<td>0.23</td>
<td>0.23</td>
<td>0.06</td>
</tr>
<tr>
<td>Salt</td>
<td></td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Choline Chloride</td>
<td></td>
<td>0.11</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Coccidiostat</td>
<td></td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Liver tonic</td>
<td></td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>Toxin Binder</td>
<td></td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Betaine</td>
<td></td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Trace mineral premix$^1$</td>
<td></td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Vitamin premix$^2$</td>
<td></td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Nutrient composition analyzed:**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pre starter (0-7 days)</th>
<th>Starter (8-21 days)</th>
<th>Finisher (22-42 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.P. %</td>
<td>23.20</td>
<td>22.29</td>
<td>20.13</td>
</tr>
<tr>
<td>Ca%</td>
<td>1.09</td>
<td>0.93</td>
<td>0.89</td>
</tr>
<tr>
<td>Total P %</td>
<td>0.77</td>
<td>0.45</td>
<td>0.43</td>
</tr>
</tbody>
</table>

**Nutrient composition calculated:**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pre starter (0-7 days)</th>
<th>Starter (8-21 days)</th>
<th>Finisher (22-42 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal ME/kg diet)</td>
<td>3000</td>
<td>3101</td>
<td>3203</td>
</tr>
<tr>
<td>Lysine%</td>
<td>1.33</td>
<td>1.39</td>
<td>1.14</td>
</tr>
<tr>
<td>Methionine%</td>
<td>0.52</td>
<td>0.64</td>
<td>0.42</td>
</tr>
</tbody>
</table>

$^1$ Trace mineral provided per kg diet: Manganese, 120mg; Zinc, 80mg; Iron, 25mg; Copper, 10mg; Iodine, 1mg; and Selenium, 0.1mg.

$^2$ Vitamin premix provided per kg diet: Vitamin A, 20000IU; Vitamin D3, 3000IU; Vitamin E, 10mg; Vitamin K, 2mg; Riboflavin, 25mg; Vitamin B1, 1mg; Vitamin B6, 2mg; Vitamin B12, 40mcg and Niacin, 15 mg.
Feeding and Watering

The feed was offered *ad-libitum* in linear chick’s feeders. Chick’s waterer was used in each cage to offer clean and fresh water during early weeks. Due care was taken so that the chicks reach the feeder and waterer in the first week of age. Later in the experiment, large size grower feeders and waterer were attached to each cage in opposite direction. All-mash system of feeding was practiced during the experiment. Thus, in the entire study standard condition of brooding, housing, feeding and watering was maintained for all the groups.

3.2 Methods

Measurements and Observations

The following observations were recorded during the experimental period:

1. Performance of broilers

(a) **Body Weight** - The birds were weighed individually on weekly basis to know the body weight gain of broilers till six weeks of age. Weight gains in different groups of broilers were calculated on weekly basis considering the body weights of broilers, recorded during different intervals.

(b) **Feed intake** - Weekly feed consumption of broilers was recorded replicate wise on the basis of feed offered and left over feed recorded at the end of that week. During metabolic trial, separate record of feed consumption and left over feed was maintained to know the actual quantity of feed consumed by the bird in a particular group.

(c) **Feed conversion ratio (FCR)** - To calculate FCR, the body weight gain and feed consumption in each week of experiment were used and calculated using following formula:

\[
FCR = \frac{\text{Feed consumption (g)}}{\text{Body weight gain (g)}}
\]
2. **Nutrient Utilization**

To know the utilization of nutrients (DM, CP, EE, CF, NFE and GE) from different diets metabolic trial was conducted on 6th week of the experiment. Metabolic trial was conducted in battery brooder itself already equipped with feeder, waterer and faecal tray. During collection period quantity of feed offered and leftover were taken daily, to know the total feed intake per bird replicate wise. The excreta of each replicate were collected quantitatively at every 24 hours period for 3 days. From total excreta, 100gm of excreta was taken and dried in hot air oven to know the dry matter. Feed samples of each treatment and dried excreta were finely grinded replicate wise and stored for further analysis.

3. **Carcass traits**

To study the carcass traits, two broilers in each replicate were slaughtered on termination of experiment. Broilers were kept off feed for twelve hour before slaughter. During this period, they were provided clean and fresh drinking water *ad-libitum*. Before slaughter, each broiler was weighed and then by giving severe cut to the jugular vein it was killed and then allowed to bleed completely. For complete bleeding, birds were hanged in inverted position on the iron rails. After complete bleeding, weight was recorded. The weight was again recorded after manual defeathering using hot water (50-55°C). The dressed weight was then recorded as follows:

\[
\text{Dressed weight} = \text{Live weight} - \text{Weight loss as blood, head, feathers, shank and wing tips.}
\]

After recording the dressed weight, a horizontal cut was applied posterior to keel bone. Breast was pushed forward to expose the viscera which were then pulled out. Weight of carcass was recorded again. Various visceral organs like liver, heart, giblet, gizzard and pancreas were weighed. The eviscerated weight was then recorded as follows:

\[
\text{Eviscerated weight} = \text{Dressed weight} - \text{Weight of viscera}
\]

The drawn weight was then recorded as follows:

\[
\text{Drawn weight} = \text{Eviscerated weight} + \text{Weight of giblet}
\]

Various processing losses such as blood, head, feathers, shank, separable fat and wing tips were recorded replicate wise during the study.
Organs weight

The organs (liver, heart, gizzard, spleen and pancreas) collected replicate wise at the time of slaughter and their weight was recorded during the study.

4. Humoral Immune response:

Haemagglutination inhibition titre against Newcastle disease:

Broiler birds were vaccinated on 7\textsuperscript{th} day of age with F\textsubscript{1} strain, 14\textsuperscript{th} day with infectious bursal disease and 21\textsuperscript{st} of age with Lasota strain of Newcastle disease. Humoral immunity towards Newcastle disease was measured on day 30\textsuperscript{th} and 42\textsuperscript{nd} by the Haemagglutination inhibition test according to the method of Office International Des Epizooties (2005).

5. Intestinal microbial population

Standard Plate Count:

On termination of experiment to study the intestinal microbial population the caeca of two broilers from each replicate were collected from the same birds which were slaughtered for doing carcass characteristics. Both the caeca of two broilers from each replicate were aseptically removed, weighed and their contents homogenized thoroughly. One gram of caecal content was placed in 9 ml of sterile normal saline and serial tenfold dilution was prepared.

The viable number of bacteria per gram of caecal content was determined using the Standard Plate Count media (Markley \textit{et al.}, 2013).

6. Mortality

Mortality record was maintained during the entire experimental trial.

7. Economics of production

The feed cost per Kg body weight gain was calculated for each dietary treatment using average value of three replicates per treatment. The feed cost was calculated using existing market prices of feed ingredients.
Analytical methods

(a) Chemical

Feed ingredients as well as diets used in the study and excreta collected during the metabolic trial were analyzed for their proximate composition using AOAC methods (2005). Gross energy was determined by using an adiabatic bomb calorimeter by standardizing with benzoic acid.

(b) Statistical Analysis

Statistical analysis of the data was done by using analysis of variance using completely randomize design as per Snedecor and Cochran (1994). Differences among the treatments were tested for significance by Duncan’s Multiple Range Test (1955).
4. RESULTS

4.1 Effect of organic acid salts supplementation on overall performance of broilers (0-42d)

The effect of different organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) supplementation on overall performance of broilers in terms of body weight, total body weight gain, feed intake and feed conversion ratio (FCR) was calculated.

4.1.1 Average Body weight

In the present study treatment means of the average body weight (g/bird) indicated that supplementation of organic acid salts in the diets of broilers influenced their body weight significantly (Table 03) and (Fig 01).

Use of lower levels of organic acids (2%) did not influence (P>0.05) the total body weight of birds. But, increase in the level of calcium sorbate and sodium butyrate from 2 to 3% in diet increases the weight significantly (P<0.05).

Among the sodium acetate supplemented diets, higher total body weight was noted in broilers assigned T7 diet (1964.88±14.22) and lower body weight was observed in broilers assigned T2 diet (1944.00±10.62), however, they were statistically similar (P>0.05) to those assigned control diet (1982.59±27.00). Thus supplementation of 2 and 3% sodium acetate in basal diet did not influence (P>0.05) the body weight of broilers.

Among the calcium sorbate supplemented diets, maximum and significantly (P<0.05) higher body weight was observed in broilers assigned T8 diet (2198.27±16.51) when compared to control. Significantly (P<0.05) lower total body weight was observed in broilers assigned T3 diet (2020.66±15.42), however, it was statistically similar (P>0.05) to those assigned control diet (1982.59±27.00). Thus increase in the level of calcium sorbate from 2 to 3% significantly (P<0.05) influenced the body weight in broilers.
<table>
<thead>
<tr>
<th>Treatments</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
<th>Calcium sorbate (2%)</th>
<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium lactate (2%)</th>
<th>Sodium acetate (3%)</th>
<th>Calcium sorbate (3%)</th>
<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic</th>
<th>Synbiotics</th>
<th>BMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day old</td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
<td>T4</td>
<td>T5</td>
<td>T6</td>
<td>T7</td>
<td>T8</td>
<td>T9</td>
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<td>T13</td>
<td>T14</td>
</tr>
<tr>
<td></td>
<td>59.00 ±0.72</td>
<td>59.00 ±0.72</td>
<td>59.00 ±0.72</td>
<td>59.00 ±0.72</td>
<td>59.22 ±0.64</td>
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<td>59.00 ±0.61</td>
<td>59.00 ±0.61</td>
<td>59.00 ±0.61</td>
<td>59.00 ±0.61</td>
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<td>59.11 ±0.61</td>
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<tr>
<td>I</td>
<td>186.77 ±3.10</td>
<td>176.44 ±4.42</td>
<td>178.11 ±3.92</td>
<td>165.33 ±3.98</td>
<td>179.22 ±4.48</td>
<td>176.88 ±4.64</td>
<td>177.44 ±4.54</td>
<td>182.00 ±5.44</td>
<td>153.77 ±5.97</td>
<td>173.44 ±3.98</td>
<td>173.66 ±4.05</td>
<td>194.00 ±2.97</td>
<td>190.00 ±3.68</td>
<td>173.88 ±2.85</td>
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<tr>
<td>II</td>
<td>424.44 ±9.70</td>
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<td>439.33 ±6.60</td>
<td>350.88 ±7.66</td>
<td>432.77 ±10.79</td>
<td>373.27 ±7.85</td>
<td>386.55 ±4.56</td>
<td>461.44 ±12.64</td>
<td>327.77 ±11.91</td>
<td>411.11 ±12.77</td>
<td>364.22 ±6.86</td>
<td>393.16 ±10.06</td>
<td>412.11 ±6.63</td>
<td>420.00 ±8.69</td>
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<tr>
<td>III</td>
<td>740.00 ±11.08</td>
<td>739.88 ±10.30</td>
<td>795.66 ±5.09</td>
<td>719.33 ±11.79</td>
<td>769.61 ±8.90</td>
<td>719.00 ±11.77</td>
<td>769.33 ±8.13</td>
<td>816.22 ±8.13</td>
<td>735.55 ±11.93</td>
<td>772.77 ±11.18</td>
<td>656.11 ±7.95</td>
<td>751.16 ±8.82</td>
<td>777.77 ±7.17</td>
<td>786.22 ±6.97</td>
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<td>V</td>
<td>1463.66 ±24.54</td>
<td>1559.11 ±11.60</td>
<td>1608.55 ±6.90</td>
<td>1518.55 ±20.58</td>
<td>1563.66 ±18.02</td>
<td>1390.55 ±17.36</td>
<td>1569.88 ±11.74</td>
<td>1764.66 ±14.96</td>
<td>1564.22 ±13.67</td>
<td>1608.20 ±17.53</td>
<td>1263.22 ±12.89</td>
<td>1568.83 ±20.69</td>
<td>1656.88 ±12.95</td>
<td>1635.77 ±14.38</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)

24
Among the sodium butyrate supplemented diets, maximum and significantly (P<0.05) higher body weight was observed in broilers assigned T10 diet (2030.40±17.61) when compared to control and lower total body weight was observed in broilers assigned T5 diet (1989.44±16.59), however, body weight in broilers fed on T5 and T10 diets were statistically similar (P>0.05). Therefore, with increasing the supplementation of sodium butyrate from 2 to 3% led significantly (P<0.05) higher body weight of broilers in comparison to control.

Among the calcium propionate supplemented diets, maximum body weight was noted in broilers assigned T9 diet (2007.44±14.29) and lower total body weight was observed in broilers assigned T4 diet (1945.88±15.62), however, they were statistically similar (P>0.05) to those assigned control diet (1982.59±27.00). Therefore, use of 2 and 3% level of calcium propionate did not affect (P>0.05) the body weight of broilers.

Supplementation of 2% sodium lactate (1769.33±17.75) and 3% sodium lactate (1634.55±13.47) led to significant reduction in their body weight, however, they were statistically (P>0.05) lower to those assigned control diet (1982.59±27.00). Therefore, broilers fed on diets supplemented with 2 and 3% sodium lactate showed significantly (P>0.05) reduced body weight when compared to control.

Similarly, the different feed additives other than organic acid salts, probiotic, combination of prebiotic and probiotic (synbiotics) and antibiotic growth promoter improved the body weight in broilers.

Experimental groups supplemented with synbiotic (Saccharomyces boulardii + MOS) and antibiotic growth promoter (Bacitracin Methylene Disalicylate) showed significant (P<0.05) higher total body weight. Average values for total body weight of broilers fed on diets T13 and T14 are 2154.05±11.30 and 2156.50±9.84, respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter showed significantly (P<0.05) higher body weight when compared to control. However, body weight in broilers fed on diets supplemented with probiotics (1976.21±21.06) was statistically similar (P>0.05) to those assigned control diet (1982.59±27.00).
The overall results on total body weight of present study indicated that total body weight was improved (p<0.05) by dietary supplementation of 3% calcium sorbate, 3% sodium butyrate, synbiotic (Saccharomyces boulardii + MOS) and antibiotic growth promoter (Bacitracin Methylene Disalicylate) when compared with the control.

**4.1.2 Body weight gain**

In the present study treatment means of the total body weight gain (g/bird) indicated that supplementation of organic acids the diets of broilers influenced their body weight gain significantly (Table 04) and (Fig 02).

Use of lower levels of organic acids (2%) did not influence (P>0.05) the total body weight gain of birds. But, increasing in the level of calcium sorbate and sodium butyrate (3%) in diet increases the weight gain significantly (P<0.05).

Among the sodium acetate organic acid salt supplemented diets, maximum total body weight gain was noted in broilers assigned T7 diet (1905.55±14.25) and lower body weight gain was observed in broilers assigned T2 diet (1885.00±10.95), however, they were statistically similar (P>0.05) to those assigned control diet (1923.59±27.12). Thus use of 2 and 3% level of sodium acetate did not influence (P>0.05) the total body weight gain of broilers.

Among the calcium sorbate supplemented diets, maximum and significantly (P<0.05) higher total body weight gain was noted in broilers assigned T8 diet (2133.05±17.57) when compared to control. Significantly (P<0.05) lower total body weight gain was observed in broilers assigned T3 diet (1952.54±18.20), however, it was statistically similar (P>0.05) to those assigned control diet (1923.59±27.12). Thus increase in the level of calcium sorbate from 2 to 3% significantly (P<0.05) increases the weight gain in broilers.
Table 04: Average weekly body weight gain (g/bird) of broilers in different treatment groups

<table>
<thead>
<tr>
<th>Age (Wks)</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
<th>Calcium sorbate (2%)</th>
<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium acetate (3%)</th>
<th>Calcium sorbate (3%)</th>
<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic</th>
<th>Synbiotics</th>
<th>BMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>127.77 ± 2.72</td>
<td>117.44 ± 4.46</td>
<td>119.11 ± 3.56</td>
<td>106.33 ± 3.46</td>
<td>119.50 ± 4.12</td>
<td>118.11 ± 4.33</td>
<td>122.33 ± 5.17</td>
<td>94.77 ± 5.82</td>
<td>114.44 ± 3.88</td>
<td>114.66 ± 3.97</td>
<td>135.00 ± 2.73</td>
<td>131.00 ± 3.40</td>
<td>114.77 ± 2.49</td>
</tr>
<tr>
<td>II</td>
<td>237.66 ± 8.02</td>
<td>214.00 ± 4.99</td>
<td>261.22 ± 6.39</td>
<td>185.55 ± 5.09</td>
<td>253.55 ± 8.40</td>
<td>209.11 ± 5.03</td>
<td>279.44 ± 8.26</td>
<td>174.00 ± 6.88</td>
<td>237.66 ± 10.20</td>
<td>190.55 ± 7.60</td>
<td>199.16 ± 11.17</td>
<td>222.11 ± 7.29</td>
<td>246.11 ± 9.01</td>
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<tr>
<td>IV</td>
<td>339.55 ± 11.45</td>
<td>419.77 ± 9.98</td>
<td>429.33 ± 10.53</td>
<td>412.66 ± 8.16</td>
<td>386.72 ± 10.29</td>
<td>362.44 ± 8.62</td>
<td>402.05 ± 13.07</td>
<td>478.11 ± 4.77</td>
<td>403.77 ± 9.93</td>
<td>432.44 ± 12.28</td>
<td>410.50 ± 9.95</td>
<td>437.00 ± 10.84</td>
<td>437.00 ± 11.71</td>
</tr>
<tr>
<td>VI</td>
<td>452.44 ± 6.20</td>
<td>384.88 ± 12.28</td>
<td>403.00 ± 14.98</td>
<td>427.33 ± 9.20</td>
<td>424.16 ± 10.06</td>
<td>370.77 ± 15.59</td>
<td>395.00 ± 15.33</td>
<td>433.61 ± 6.73</td>
<td>422.20 ± 5.03</td>
<td>371.33 ± 15.76</td>
<td>407.38 ± 3.55</td>
<td>497.16 ± 11.03</td>
<td>520.72 ± 12.61</td>
</tr>
<tr>
<td>Total BWG</td>
<td>1923.59 ± 27.12</td>
<td>1885.86 ± 10.95</td>
<td>1952.54 ± 18.20</td>
<td>1886.88 ± 15.77</td>
<td>1928.09 ± 16.60</td>
<td>1702 ± 19.05</td>
<td>1905.55 ± 14.25</td>
<td>2133.05 ± 17.57</td>
<td>1948.44 ± 17.52</td>
<td>1971.40 ± 13.29</td>
<td>1576.11 ± 21.04</td>
<td>2095.05 ± 11.11</td>
<td>2097.3 ± 9.80</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
Among the calcium propionate supplemented diets, maximum body weight gain was noted in broilers assigned T9 diet (1948.44 ±13.95) and lower total body weight gain was observed in broilers assigned T4 diet (1886.88 ±15.77), however, they were statistically similar (P>0.05) to those assigned control diet (1923.59±27.12). Thus use of 2 and 3% level of calcium propionate did not influence (P>0.05) the weight gain of broilers.

Among the sodium butyrate supplemented diets, maximum and significantly (P<0.05) higher total body weight gain was noted in broilers assigned T10 diet (1971.40 ±17.52) when compared to control and lower total body weight gain was observed in broilers assigned T5 diet (1928.09 ±16.60), however, total body weight gain in T5 and T10 diets were statistically similar (P>0.05). Therefore, increase in the level of sodium butyrate from 2 to 3% significantly (P<0.05) increased the weight gain in broilers in comparison to control.

Use of 2% sodium lactate (1702±19.05) and 3% sodium lactate (1576.11±13.29) led to significant reduction in their total body weight gain, however, they were statistically (P<0.05) lower to those assigned control diet (1923.59±27.12). Therefore, broilers fed on diets supplemented with 2 and 3% of sodium lactate significantly (P<0.05) reduced their total body weight gain when compared to control.

Similarly, the different feed additives other than organic acid salts, probiotic, combination of prebiotic and probiotic (synbiotics) and antibiotic growth promoter improved the total body weight gain in broilers.

Experimental groups supplemented with synbiotic \((Saccharomyces boulardii + MOS)\) and antibiotic growth promoter (Bacitracin Methylene Disalicylate) showed significantly (P<0.05) higher total body weight gain. Average values for total body weight gain of broilers fed on diets T13 and T14 are (2095.05±11.11) and (2097.38±9.80), respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter significantly (P<0.05) increased their body weight gain when compared to control. However, total body weight gain in broilers fed on diets supplemented with probiotics (1917.21±21.04) was statistically similar (P>0.05) to those assigned control diet (1923.59±27.12).
The overall results on total body weight gain of present study indicated that the broilers total body weight gain were improved (P<0.05) by dietary supplementation of 3% calcium sorbate, 3% sodium butyrate, synbiotic (*Saccharomyces boulardii* + MOS) and antibiotic growth promoter (Bacitracin Methylene Disalicylate) when compared with the control.

### 4.1.3 Feed intake

The weekly feed consumption by birds in all the treatment groups was recorded during the entire experimental period. The values of feed intake calculated at weekly intervals as g/bird were presented below in (Table 05) and (Fig 03).

The values for overall feed intake when organic acids viz. sodium acetate (T2), calcium sorbate (T3), calcium propionate (T4) and sodium butyrate (T5) were supplemented at 2% are 3693.65±25.82, 3728.28±39.42, 3725.40±30.78 and 3787.33±23.33, respectively. However, they were statistically similar (P>0.05) to those assigned control diet (3788.01±28.42) and lower feed intake was reported in birds fed on diet T6 (3677.88±27.01).

The values for overall feed intake when organic acids viz. sodium acetate (T7), calcium sorbate (T8), calcium propionate (T9) and sodium butyrate (T10) were supplemented at 3% are 3672.86±28.11, 3785.26±27.90, 3734.78±27.63 and 3755.50±33.25, respectively. However, they were statistically similar (P>0.05) to those assigned control diet (3788.01±28.42) and significantly (P<0.05) lowest feed intake was reported in birds fed on diet T11 (3563.92±26.99).

Experimental groups supplemented with probiotic, synbiotic and antibiotic growth promoter did not showed any effect on feed intake of broilers. Overall feed consumption of broilers fed on diets T12, T13 and T14 are 3775.43±23.45, 3773.27±23.07 and 3762.97±20.39, respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter did not influence the feed intake of broilers when compared to control.
Table 05: Average weekly feed intake (g/bird) of broilers in different treatment groups

<table>
<thead>
<tr>
<th>Age (Wks)</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
<th>Calcium sorbate (2%)</th>
<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium acetate (3%)</th>
<th>Calcium sorbate (3%)</th>
<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic</th>
<th>Synbiotics</th>
<th>BMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>T1</td>
<td>201.89 ±4.36</td>
<td>183.41 ±6.72</td>
<td>181.52 ±5.54</td>
<td>166.66 ±6.36</td>
<td>191.82 ±6.94</td>
<td>181.23 ±6.75</td>
<td>174.01 ±7.23</td>
<td>141.29 ±8.78</td>
<td>170.07 ±5.28</td>
<td>195.65</td>
<td>205.73</td>
<td>160.81</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>201.89 ±4.36</td>
<td>183.41 ±6.72</td>
<td>181.52 ±5.54</td>
<td>166.66 ±6.36</td>
<td>191.82 ±6.94</td>
<td>181.23 ±6.75</td>
<td>174.01 ±7.23</td>
<td>141.29 ±8.78</td>
<td>170.07 ±5.28</td>
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<td>191.82 ±6.94</td>
<td>181.23 ±6.75</td>
<td>174.01 ±7.23</td>
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<td>191.82 ±6.94</td>
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<td>191.82 ±6.94</td>
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<td>174.01 ±7.23</td>
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<td>191.82 ±6.94</td>
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<td>191.82 ±6.94</td>
<td>181.23 ±6.75</td>
<td>174.01 ±7.23</td>
<td>141.29 ±8.78</td>
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<td>174.01 ±7.23</td>
<td>141.29 ±8.78</td>
<td>170.07 ±5.28</td>
<td>195.65</td>
<td>205.73</td>
<td>160.81</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
The overall results on total feed intake of present study in broilers indicated that feed intake was not influenced by dietary supplementation of 2 and 3% organic acids (sodium acetate, calcium sorbate, calcium propionate and sodium butyrate), probiotic, synbiotic and antibiotic growth promoter when compared with the control.

**4.1.4 Feed Conversion Ratio**

In the present study treatment means of the feed conversion ratio indicated that supplementation of organic acids in the diets of broilers influenced their feed conversion ratio significantly as presented below in the (Table 06) and (Fig 04).

Use of lower levels of organic acids (2%) did not influence (P>0.05) the feed conversion ratio of birds. But, increasing in the level of calcium sorbate and sodium butyrate (3%) in diet increases the feed conversion ratio significantly (P<0.05).

Among the sodium acetate supplemented diets, significantly lowest and better (P<0.05) feed conversion ratio was found in broilers assigned T7 diet (1.92±0.02) and low feed conversion ratio was observed in broilers assigned T2 diet (1.96±0.01), however, it was statistically similar (P>0.05) to those assigned control diet (1.96±0.02). Therefore, increase in the level of sodium acetate from 2 to 3% significantly (P<0.05) improves the feed conversion ratio of broilers in comparison to control.

Among the calcium sorbate supplemented diets, significantly lowest and better (P<0.05) feed conversion ratio was noted in broilers assigned T8 diet (1.77±0.02) when compared to control. Significantly (P<0.05) lower feed conversion ratio was observed in broilers assigned T3 diet (1.90±0.01) than the broilers fed control diet (1.96±0.02). Thus supplementation of calcium sorbate (2% or 3%) significantly (P<0.05) influenced the feed conversion ratio in broilers, however, best conversion was found by supplementation of calcium sorbate at 3% level.
Table 06: Average weekly feed conversion ratio of broilers in different treatment groups

<table>
<thead>
<tr>
<th>Age (Wks)</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
<th>Calcium sorbate (2%)</th>
<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium lactate (2%)</th>
<th>Sodium acetate (3%)</th>
<th>Calcium sorbate (3%)</th>
<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic</th>
<th>Symbiotics</th>
<th>BMD</th>
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<tr>
<td>I</td>
<td>1.58±0.01</td>
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<td>1.52±0.01</td>
<td>1.56±0.01</td>
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<td>1.48±0.01</td>
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<td>II</td>
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<td>1.93±0.01</td>
<td>1.64±0.01</td>
<td>1.59±0.01</td>
<td>1.63±0.01</td>
<td>1.93±0.01</td>
<td>1.76±0.03</td>
<td>1.57±0.01</td>
<td>1.59±0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>1.91±0.02</td>
<td>1.91±0.02</td>
<td>1.84±0.01</td>
<td>1.89±0.01</td>
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<td>1.89±0.01</td>
<td>1.71±0.01</td>
<td>1.81±0.01</td>
<td>1.84±0.01</td>
<td>2.19±0.01</td>
<td>1.89±0.01</td>
<td>1.75±0.01</td>
<td>1.76±0.01</td>
</tr>
<tr>
<td>IV</td>
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<td>1.94±0.01</td>
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<td>1.99±0.01</td>
<td>2.18±0.03</td>
<td>1.97±0.01</td>
<td>1.81±0.01</td>
<td>1.93±0.02</td>
<td>1.93±0.01</td>
<td>2.36±0.02</td>
<td>1.98±0.01</td>
<td>1.83±0.01</td>
<td>1.79±0.01</td>
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<td>V</td>
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<td>2.03±0.01</td>
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<td>2.27±0.01</td>
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<tr>
<td>VI</td>
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<td>2.09±0.01</td>
<td>2.40±0.01</td>
<td>2.07±0.01</td>
<td>1.91±0.01</td>
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<td>2.08±0.01</td>
<td>2.55±0.01</td>
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<td>1.93±0.01</td>
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<td>Overall FCR</td>
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<td>1.96±0.01</td>
<td>1.96±0.01</td>
<td>1.97±0.03</td>
<td>1.96±0.02</td>
<td>2.16±0.03</td>
<td>1.92±0.02</td>
<td>1.77±0.02</td>
<td>1.91±0.01</td>
<td>1.90±0.01</td>
<td>2.26±0.02</td>
<td>1.96±0.03</td>
<td>1.8±0.01</td>
<td>1.79±0.03</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
Among the calcium propionate supplemented diets, significantly lowest and better (P<0.05) feed conversion ratio was noted in broilers assigned T9 diet (1.91±0.01) and lower feed conversion ratio was observed in broilers assigned T4 diet (1.97±0.03), however, it was statistically similar (P>0.05) to those assigned control diet (1.96±0.02). Thus increasing the level of calcium propionate from 2 to 3% significantly improves (P>0.05) the feed conversion ratio of broilers.

Among the sodium butyrate supplemented diets, significantly lowest and better (P<0.05) feed conversion ratio was noted in broilers assigned T10 diet (1.90±0.01) when compared to control and lower feed conversion ratio was observed in broilers assigned T5 diet (1.96±0.02), however, it was statistically similar (P>0.05) to those assigned control diet (1.96±0.02). Therefore, increase in the level of sodium butyrate from 2 to 3% significantly (P>0.05) improves the feed conversion ratio of broilers in comparison to control.

Use of 2% sodium lactate (2.16±0.03) and 3% sodium lactate (2.26±0.02) led to significant increase in their feed conversion ratio, however, statistically lower and better (P<0.05) feed conversion ratio was observed in broilers assigned control diet (1.96±0.02). Therefore, broilers fed on diets supplemented with 2 and 3% of sodium lactate led to significantly (P<0.05) increase in their feed conversion ratio when compared to control.

Similarly, different feed additives other than organic acid salts, probiotic, antibiotic growth promoter and combination of prebiotic and probiotic (synbiotics) improved the feed conversion ratio in broilers.

Experimental groups supplemented with synbiotic and antibiotic growth promoter showed better feed conversion ratio. Average values for feed conversion ratio of broilers fed on diets T13 and T14 are (1.8±0.01) and (1.79±0.03), respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter significantly (P<0.05) improved the feed conversion ratio in broilers when compared to control. However, feed conversion ratio in broilers fed on diets supplemented with probiotics (1.96±0.03) was statistically similar (P>0.05) to those assigned control diet (1.96±0.02).
The overall results on feed conversion ratio of present study in broilers indicated that feed conversion ratio was significantly improved (P<0.05) by dietary supplementation of 2% and 3% calcium sorbate, 3% calcium propionate, 3% sodium butyrate, 3% sodium acetate, synbiotic and antibiotic growth promoter when compared with the control.

4.2 RETENTION OF NUTRIENTS

Effect of organic acid salts supplementation on nutrients digestibility in terms of dry matter, crude protein, ether extract, crude fiber, nitrogen free extract and gross energy in broilers at 42 days of age is furnished in Table 07. Organic acid salts supplementation were found to have significant (P<0.05) influence on the digestibility of nutrients.

4.2.1 Effect of feeding organic acid salts supplementation on dry matter digestibility of broiler chicks

Among organic acid salts supplemented diets, digestibility of dry matter (DM) were not influenced by the lower level of supplementation (2%), therefore, dry matter digestibility in birds fed on diets T2 (68.62±0.25), T4 (68.65±0.51), T5 (69.95±0.03) and T6 (69.45±0.10) were found statistically (P>0.05) similar to control diet except T3 (69.99±0.23) diet which was significantly (P<0.05) higher (Table 07) and (Fig 05).

Use of higher levels of organic acid salts supplementation (3%) tends to improve the digestibility of dry matter (%) in broilers (Table 07). Maximum and significantly (P<0.05) higher dry matter digestibility was noted in broilers fed on T8 diet (72.27±0.38). Further, dry matter digestibility in birds fed on diets T7 (70.37±0.30), T9 (70.01±0.28) and T10 (70.10±0.08) were found statistically (P>0.05) similar but significantly (P<0.05) higher when compared with the control T1 (69.19±0.21). Minimum and significantly (P<0.05) lower dry matter digestibility was observed in broilers assigned T11 (68.12±0.15) diet.
Table 07: Nutrient utilization (%) of broilers in different treatment groups

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
<th>Calcium sorbate (2%)</th>
<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium acetate (3%)</th>
<th>Calcium sorbate (3%)</th>
<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic</th>
<th>Synbiotics</th>
<th>BMD</th>
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<tr>
<td>DM</td>
<td>69.19&lt;sup&gt;ab&lt;/sup&gt; ±0.21</td>
<td>68.62&lt;sup&gt;b&lt;/sup&gt; ±0.25</td>
<td>69.99&lt;sup&gt;bc&lt;/sup&gt; ±0.23</td>
<td>68.65&lt;sup&gt;h&lt;/sup&gt; ±0.51</td>
<td>69.95&lt;sup&gt;cd&lt;/sup&gt; ±0.03</td>
<td>69.45&lt;sup&gt;de&lt;/sup&gt; ±0.10</td>
<td>70.37&lt;sup&gt;c&lt;/sup&gt; ±0.30</td>
<td>72.27&lt;sup&gt;a&lt;/sup&gt; ±0.38</td>
<td>70.01&lt;sup&gt;bc&lt;/sup&gt; ±0.28</td>
<td>70.10&lt;sup&gt;bc&lt;/sup&gt; ±0.08</td>
<td>68.12&lt;sup&gt;g&lt;/sup&gt; ±0.15</td>
<td>69.15&lt;sup&gt;ef&lt;/sup&gt; ±0.08</td>
<td>72.55&lt;sup&gt;a&lt;/sup&gt; ±0.18</td>
</tr>
<tr>
<td>CP</td>
<td>79.52&lt;sup&gt;h&lt;/sup&gt; ±0.38</td>
<td>79.34&lt;sup&gt;g&lt;/sup&gt; ±0.23</td>
<td>81.28&lt;sup&gt;d&lt;/sup&gt; ±0.17</td>
<td>79.98&lt;sup&gt;h&lt;/sup&gt; ±0.13</td>
<td>80.62&lt;sup&gt;de&lt;/sup&gt; ±0.31</td>
<td>77.78&lt;sup&gt;h&lt;/sup&gt; ±0.69</td>
<td>81.25&lt;sup&gt;d&lt;/sup&gt; ±0.19</td>
<td>83.05&lt;sup&gt;c&lt;/sup&gt; ±0.39</td>
<td>80.83&lt;sup&gt;de&lt;/sup&gt; ±0.38</td>
<td>81.48&lt;sup&gt;bc&lt;/sup&gt; ±0.61</td>
<td>76.63&lt;sup&gt;b&lt;/sup&gt; ±0.67</td>
<td>80.12&lt;sup&gt;de&lt;/sup&gt; ±0.08</td>
<td>82.57&lt;sup&gt;cd&lt;/sup&gt; ±0.30</td>
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<tr>
<td>EE</td>
<td>88.07 ±0.49</td>
<td>88.18 ±0.10</td>
<td>89.00 ±0.21</td>
<td>87.28 ±0.76</td>
<td>88.04 ±0.35</td>
<td>88.00 ±1.45</td>
<td>88.35 ±0.72</td>
<td>86.35 ±1.16</td>
<td>87.80 ±1.82</td>
<td>87.54 ±0.28</td>
<td>87.79 ±0.99</td>
<td>87.38 ±0.13</td>
<td>88.83 ±0.10</td>
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<tr>
<td>CF</td>
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<td>29.11 ±0.55</td>
<td>29.17 ±0.65</td>
<td>28.93 ±0.36</td>
<td>28.68 ±0.48</td>
<td>28.66 ±0.25</td>
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<td>29.02 ±0.15</td>
<td>28.16 ±0.28</td>
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<td>29.07 ±0.29</td>
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<td>NFE</td>
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<td>89.20±0.59</td>
<td>88.59±0.80</td>
<td>90.45±0.62</td>
<td>90.98±0.39</td>
<td>89.43±0.38</td>
<td>89.15±0.57</td>
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<tr>
<td>GE</td>
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<td>66.55±0.13</td>
<td>69.10±0.09</td>
<td>66.15±0.10</td>
<td>67.20±0.23</td>
<td>60.24±0.13</td>
<td>63.19±0.12</td>
<td>69.03±0.32</td>
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</table>

Means of row with different superscript showing significant difference at (P<0.05)
Similarly, different feed additives other than organic acid salts, antibiotic growth promoter and combination of prebiotic and probiotic (synbiotics) improved the dry matter digestibility in broilers.

Experimental groups supplemented with synbiotic and antibiotic growth promoter showed better dry matter digestibility. Average values for dry matter digestibility of broilers fed on diets T13 and T14 are (72.55±0.18) and (72.04±0.09), respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter significantly (P<0.05) improved the dry matter digestibility in broilers when compared to control. However, dry matter digestibility in broilers fed on diets supplemented with probiotics (69.15±0.08) was statistically similar (P>0.05) to those assigned control diet (69.19±0.21).

4.2.2 Effect of feeding organic acid salts supplementation on crude protein digestibility of broiler chicks

Digestibility of crude protein (CP) influenced by inclusion of organic acid salts (2 and 3% sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) in broiler diets is given in (Table 07) and (Fig 05).

Among organic acid salts supplemented diets, digestibility of crude protein (CP) were not influenced by the lower level of supplementation (2%), therefore, CP digestibility in birds fed on diets T2 (79.34±0.23), T4 (79.98±0.13) and T5 (80.62±0.31) were found statistically (P>0.05) similar to control diet except T3 (81.28±0.17) diet which was significantly (P<0.05) higher. Minimum and significantly (P<0.05) lower CP digestibility was observed in broilers assigned T6 (77.78±0.69) diet.

Use of higher levels of organic acid salts supplementation (3%) tends to improve the digestibility of CP (%) in broilers (Table 07). Maximum and significantly (P<0.05) higher CP digestibility was noted in broilers fed on T8 (83.05±0.39) diet. Further, CP digestibility in birds fed on diets T7 (81.25±0.19), T9 (80.83±0.38) and T10 (81.48±0.61) were found statistically (P>0.05) similar but significantly (P<0.05) higher when compared with the control. Minimum and significantly (P<0.05) lower CP digestibility was observed in broilers assigned T11 (76.63±0.67) diet.
Similarly, different feed additives other than organic acid salts, antibiotic growth promoter and combination of prebiotic and probiotic (synbiotics) improved the CP digestibility in broilers.

Experimental groups supplemented with synbiotic and antibiotic growth promoter showed better CP digestibility. Average values for CP digestibility of broilers fed on diets T13 and T14 are (82.57±0.30) and (82.73±0.23), respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter significantly (P<0.05) improved the CP digestibility when compared to control. However, CP digestibility in broilers fed on diets supplemented with probiotic T12 (80.12 ±0.08) was statistically similar (P> 0.05) to those assigned control diet T1 (79.52±0.38).

4.2.3 Effect of feeding organic acid salts supplementation on Ether extract digestibility of broiler chicks

Among organic acid salts supplemented diets, inclusion of 2 and 3% sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate did not influence (P>0.05) the digestibility of ether extract in broilers (Table 07) and (Fig 05). Hence, digestibility of EE in all supplemented diets was found statistically similar (P>0.05).

Similarly, ether extract digestibilities in broilers fed on diets supplemented with probiotics, synbiotic and antibiotic growth promoter were statistically similar (P> 0.05) to those assigned control diet.

4.2.4 Effect of feeding organic acid salts supplementation on crude fiber digestibility of broiler chicks

Among organic acid salts supplemented diets, inclusion of 2 and 3% sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate did not influence (P>0.05) the digestibility of crude fibre in broilers (Table 07) and (Fig 05). Hence, digestibility of crude fibre (CF) in all supplemented diets was found statistically similar (P>0.05).

Similarly, crude fibre digestibility in broilers fed on diets supplemented with probiotics, synbiotic and antibiotic growth promoter were statistically similar (P> 0.05) to those assigned control diet.
4.2.5 Effect of feeding organic acid salts supplementation on nitrogen free extract digestibility of broiler chicks

Among organic acid salts supplemented diets, inclusion of 2 and 3% sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate did not influence (P>0.05) the digestibility of nitrogen free extract (NFE) in broilers (Table 07) and (Fig 05). Hence, digestibility of nitrogen free extract in all supplemented diets was found statistically similar (P>0.05).

Similarly, nitrogen free extract digestibility in broilers fed on diets supplemented with probiotic, synbiotic and antibiotic growth promoter were statistically similar (P> 0.05) to those assigned control diet.

4.2.6 Effect of feeding organic acid salts supplementation on gross energy digestibility of broiler chicks

Digestibility of gross energy influenced by inclusion of organic acid salts (2 and 3% sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) in broiler diets is given in (Table 07) and (Fig 05).

Among organic acid salts supplemented diets, digestibility of gross energy (GE) were not influenced by the lower level of supplementation (2%), therefore, GE digestibility in birds fed on diets T2 (63.03±0.16), T4 (63.18±0.21) and T5 (63.22±0.10) were found statistically (P>0.05) similar to control diet except T3 (66.70±0.10) diet which was significantly (P<0.05) higher. Minimum and significantly (P<0.05) lower GE digestibility was observed in broilers assigned T6 (61.08±0.20) diet.

Use of higher levels of organic acid salts supplementation (3%) tends to improve the digestibility of GE (%) in broilers. Maximum and significantly (P<0.05) higher GE digestibility was noted in broilers fed on T8 (69.10 ±0.09) diet followed by T10 (67.20±0.23) diet. Further, GE digestibility in birds fed on diets T7 (66.55±0.13) and T9 (66.15±0.10) were found statistically (P>0.05) similar but significantly (P<0.05) higher when compared with the control (63.10±0.21). Minimum and significantly (P<0.05) lower GE digestibility was observed in broilers assigned T11 (60.24 ±0.13) diet.
Similarly, different feed additives other than organic acid salts, antibiotic growth promoter and combination of prebiotic and probiotic (synbiotics) improved the GE digestibility in broilers.

Experimental groups supplemented with synbiotic and antibiotic growth promoter showed better GE digestibility. Average values for GE digestibility of broilers fed on diets T13 and T14 are (69.03±0.32) and (69.40±0.11), respectively. Therefore, broilers fed on diets supplemented with synbiotic and antibiotic growth promoter significantly (P<0.05) improved the GE digestibility when compared to control. However, GE digestibility in broilers fed on diets supplemented with probiotics T12 (63.19±0.12) was statistically similar (P>0.05) to those assigned control diet T1 (63.10±0.21).

4.3 CARCASS TRAITS OF BROILERS

Effect of organic acid salts supplementation on carcass traits of broilers in terms of carcass yield, organs weight and processing losses in broilers at 42 days of age is furnished in Table 08 and Fig 06.

4.3.1 Effect of feeding organic acid salts supplementation on carcass yields (% of live weight) of broilers

Dressing weight (% of live weight)

Treatment means of carcass yields in terms of dressing percentage showed that organic acid salts supplementation did not influence (P>0.05) the dressing percentage of broilers significantly as presented below in Table 08 and Fig 06.

Among organic acid salts supplemented diets, dressing percentages are T2 (79.98±1.26), T3 (78.98±1.58), T4 (79.46±1.16), T5 (79.14±1.02), T6 (78.99±1.02), T7 (79.88±2.37), T8 (78.69±1.44), T9 (80.37±1.67), T10 (78.43±0.72) and T11 (80.01±1.31). Statistical analysis of data revealed that dressing percentage of all organic acid salts supplemented diets were statistically similar (P>0.05) to those assigned control diet T1 (78.19±1.41).
Table 08: Carcass yields (% of live weight) of broilers in different treatment groups

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments</th>
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<td></td>
<td>Control Diet (2%)</td>
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<td></td>
<td>Sodium acetate (2%)</td>
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<td></td>
<td>Calcium propionate (2%)</td>
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<tr>
<td></td>
<td>Sodium butyrate (2%)</td>
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<td>Sodium lactate (2%)</td>
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<td>Sodium acetate (3%)</td>
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<td>Calcium propionate (3%)</td>
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<td>Sodium butyrate (3%)</td>
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<tr>
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<td>Sodium lactate (3%)</td>
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<td>T7</td>
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<tr>
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<td>T9</td>
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<tr>
<td>T10</td>
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</tr>
<tr>
<td>T11</td>
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<tr>
<td>T13</td>
<td>78.83 ± 1.01</td>
</tr>
<tr>
<td>T14</td>
<td>79.32 ± 0.34</td>
</tr>
<tr>
<td>Dress weight %</td>
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<tr>
<td>Eviscerated weight%</td>
<td>71.82 ± 1.39</td>
</tr>
<tr>
<td>Drawn weight %</td>
<td>66.01 ± 1.46</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
Similarly, carcass yields in terms of dressing percentage in broilers fed on diets supplemented with probiotic T12 (79.02±2.09), synbiotic T13 (78.83±1.01) and antibiotic growth promoter T14 (79.32±0.34), are also statistically similar to those assigned control diet T1 (78.19±1.41).

**Eviscerated weight (% of live weight)**

Treatment means of carcass yields in terms of eviscerated weight (% of live weight) showed that organic acid salts supplementation did not influence (P>0.05) the eviscerated weight (% of live weight) of broilers significantly as presented below in Table 08 and Fig 06.

Among organic acid salts supplemented diets, eviscerated weight (% of live weight) are T2 (71.82±1.39), T3 (71.17±2.15), T4 (70.73±0.65), T5 (70.61±0.98), T6 (69.96±1.39), T7 (71.87±2.16), T8 (71.18±1.73), T9 (72.14±1.76), T10 (70.12±1.15) and T11 (70.81±1.88). Statistical analysis of data revealed that eviscerated weight (% of live weight) of all organic acid salts supplemented diets were statistically similar (P>0.05) to those assigned control diet T1 (69.74±1.50).

Similarly, carcass yields in terms of eviscerated weight (% of live weight) in broilers fed on diets supplemented with probiotic T12 (72.93±1.22), synbiotic T13 (71.06±2.88) and antibiotic growth promoter T14 (71.36±1.38), respectively, all are statistically similar to those assigned control diet T1 (69.74±1.50).

**Drawn weight (% of live weight)**

Treatment means of carcass yields in terms of drawn weight (% of live weight) showed that organic acid salts supplementation did not influence (P>0.05) the drawn weight (% of live weight) of broilers significantly as presented below in Table 08 and Fig 06.

Among organic acid salts supplemented diets, drawn weight (% of live weight) were T2 (68.02±1.34), T3 (67.43±2.16), T4 (66.87±0.61), T5 (66.73±0.98), T6 (66.15±1.39), T7 (68.02±2.12), T8 (67.33±1.66), T9 (68.28±1.75), T10 (66.31±1.10) and T11 (67.12±1.88). Statistical analysis of data revealed that drawn weight (% of live weight) of all organic acid salts supplemented diets were statistically similar (P>0.05) to those assigned control diet T1 (66.01±1.46).
Similarly, drawn weight (% of live weight) in broilers fed on diets supplemented with probiotic T12 (69.14±1.15), synbiotic T13 (67.15±2.85) and antibiotic growth promoter T14 (67.46±1.38), respectively are statistically similar to those assigned control diet T1 (66.01±1.46).

4.3.2 Effect of feeding organic acid salts supplementation on organs weight (% of dress weight) of broilers

Heart

Supplementation of organic acid at 2 or 3% levels in broilers diet did not influence (P>0.05) the heart % of broilers significantly as presented below in Table 09 and Fig 07. Among organic acid salts supplemented diets, heart % were T2 (0.51±0.05), T3 (0.45±0.02), T4 (0.50±0.02), T5 (0.49±0.03), T6 (0.48±0.02), T7 (0.52±0.03), T8 (0.51±0.03), T9 (0.53±0.03), T10 (0.49±0.02) and T11 (0.44±0.02). Hence, its weight in all diets (T2, T3, T4, T5, T6, T7, T8, T9, T10 and T11) were found statistically (P>0.05) similar when compared to control.

Similarly, heart percentage in broilers fed on diets supplemented with probiotic (T12), synbiotic (T13) and antibiotic growth promoter (T14) are 0.47±0.04, 0.50±0.02 and 0.51±0.02, respectively, are statistically (P>0.05) similar to those assigned control diet T1 (0.46±0.02).

Gizzard

Supplementation of organic acid at 2 or 3% levels in broilers diet did not influence (P>0.05) the gizzard % of broilers significantly as presented below in Table 09 and Fig 07. Among organic acid salts supplemented diets, gizzard % (% of dress weight) were T2 (1.63±0.03), T3 (1.61±0.03), T4 (1.64±0.03), T5 (1.66±0.02), T6 (1.62±0.04), T7 (1.62±0.02), T8 (1.59±0.03), T9 (1.62±0.03), T10 (1.63±0.02) and T11 (1.59±0.03). Hence, its weight in all diets (T2, T3, T4, T5, T6, T7, T8, T9, T10 and T11) were found statistically (P>0.05) similar when compared to control.
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<th>Organ</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
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<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium lactate (2%)</th>
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<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic T11</th>
<th>Synbiotics T12</th>
<th>BMD T13</th>
<th>T14</th>
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<td>Heart %</td>
<td>0.46 ±0.02</td>
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<td>Gizzard %</td>
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<td>Liver %</td>
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<td>Spleen %</td>
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<td>Pancreas %</td>
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<td>Giblet %</td>
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<td>3.80 ±0.06</td>
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<td>3.89 ±0.02</td>
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<td>3.90 ±0.04</td>
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</table>

Means of row with different superscript showing significant difference at (P<0.05)
Similarly, gizzard % (% of dress weight) in broilers fed on diets supplemented with probiotic (T12), synbiotic (T13) and antibiotic growth promoter (T14) are, 1.59±0.03, 1.65±0.02 and 1.63±0.02 respectively, are statistically (P>0.05) similar to those assigned control diet T1 (1.63±0.03).

Liver

Supplementation of organic acid at 2 or 3% levels in broilers diet did not influence (P>0.05) the liver % of broilers significantly as presented below in Table 09 and Fig 07. Among organic acid salts supplemented diets, liver % (% of dress weight) were T2 (1.66±0.05), T3 (1.68±0.02), T4 (1.72±0.04), T5 (1.73±0.03), T6 (1.72±0.02), T7 (1.72±0.02), T8 (1.74±0.05), T9 (1.71±0.03), T10 (1.68±0.02) and T11 (1.66±0.03). Hence, its weight in all diets (T2, T3, T4, T5, T6, T7, T8, T8, T9, T10 and T11) were found statistically (P>0.05) similar when compared to control (1.66±0.04).

Similarly, liver % (% of dress weight) in broilers fed on diets supplemented with probiotics (T12), synbiotic (T13) and antibiotic growth promoter (T14) are, 1.72±0.04, 1.75±0.03 and 1.76±0.03 respectively, are statistically (P>0.05) similar to those assigned control diet T1 (1.66±0.04).

Spleen

Supplementation of organic acid at 2 or 3% levels in broilers diet did not influence (P>0.05) the spleen % of broilers significantly as presented below in Table 09 and Fig 07. Among organic acid salts supplemented diets, spleen % (% of dress weight) were T2 (0.16±0.01), T3 (0.15±0.01), T4 (0.16±0.01), T5 (0.19±0.01), T6 (0.16±0.02), T7 (0.18±0.01), T8 (0.19±0.01), T9 (0.18±0.02), T10 (0.14±0.02) and T11 (0.16±0.01). Hence, its weight in all diets (T2, T3, T4, T5, T6, T7, T8, T8, T9, T10 and T11) were found statistically (P>0.05) similar when compared to control (0.17±0.01).

Similarly, spleen % (% of dress weight) in broilers fed on diets supplemented with probiotic (T12), synbiotic (T13) and antibiotic growth promoter (T14) are 0.16±0.01, 0.19±0.01 and 0.19±0.01 respectively, are statistically (P>0.05) similar to those assigned control diet T1 (0.17±0.01).
**Pancreas**

Supplementation of organic acid at 2 or 3% levels in broilers diet did not influence (P>0.05) the pancreas % of broilers significantly as presented below in Table 09 and Fig 07. Among organic acid salts supplemented diets, pancreas % (% of dress weight) were T2 (0.18 ±0.01), T3 (0.16±0.01), T4 (0.19±0.01), T5 (0.19±0.01), T6 (0.19±0.03), T7 (0.19±0.01), T8 (0.19±0.01), T9 (0.19±0.01), T10 (0.19±0.02) and T11 (0.15±0.01). Hence, its weight in all diets (T2, T3, T4, T5, T6, T7, T8, T9, T10 and T11) were found statistically (P>0.05) similar when compared to control (0.18±0.01).

Similarly, pancreas % (% of dress weight) in broilers fed on diets supplemented with probiotic (T12), synbiotic (T13) and antibiotic growth promoter (T14) are 0.19±0.01, 0.17±0.01 and 0.20±0.01 respectively, are statistically (P>0.05) similar to those assigned control diet T1 (0.18±0.01).

**Giblet**

Supplementation of organic acid at 2 or 3% levels in broilers diet did not influence (P>0.05) the giblet % of broilers significantly as presented below in Table 09 and Fig 07. Among organic acid salts supplemented diets, giblet % (% of dress weight) were T2 (3.80 ±0.06), T3 (3.74±0.01), T4 (3.89±0.02), T5 (3.88±0.03), T6 (3.81±0.02), T7 (3.85±0.04), T8 (3.85±0.09), T9 (3.86±0.04), T10 (3.81±0.05) and T11 (3.69±0.01). Hence, its weight in all diets (T2, T3, T4, T5, T6, T7, T8, T9, T10 and T11) were found statistically (P>0.05) similar when compared to control (3.71±0.03).

Similarly, giblet % (% of dress weight) in broilers fed on diets supplemented with probiotic (T12), synbiotic (T13) and antibiotic growth promoter (T14) are 3.78±0.07, 3.90±0.04 and 3.94±0.03 respectively, are statistically (P>0.05) similar to those assigned control diet T1 (3.71±0.03).
4.3.3 Effect of feeding organic acid salts supplementation on processing loss (% of live weight) of broilers

Treatment means of the processing losses indicated that blood, shank, feather and wing tips losses were not influenced by the supplementation of organic acids either at 2 or 3% as presented below in Table 10 and Fig 08. Among organic acid salts supplemented diets, processing loss were T2 (20.03±1.26), T3 (21.01±1.57), T4 (20.55±1.15), T5 (20.85±1.02), T6 (21.01±1.01), T7 (19.72±1.98), T8 (21.32±1.44), T9 (19.66±1.65), T10 (21.56±0.73) and T11 (20.01±1.30), all are statistically similar to those assigned control diet T1 (21.24±0.87). Hence, organic acid salts supplementation did not influence (P>0.05) the processing loss of boilers.

Similarly, processing loss in broilers fed on diets supplemented with probiotic (T12), synbiotic (T13) and antibiotic growth promoter (T14) are19.72±1.26, 20.99±2.07 and 21.18±0.99 respectively. Statistical analysis for processing loss revealed no significant (P>0.05) effect to those assigned control diet T1 (21.24±0.87).
Table 10: Processing losses (% of live weight) of broilers in different treatment groups

<table>
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<tr>
<th>Parameter</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
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<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
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<th>Calcium sorbate (3%)</th>
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<th>Symbiotics</th>
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<tr>
<td>Blood %</td>
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<td>3.02 ±0.18</td>
<td>2.91 ±0.23</td>
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<td>2.90 ±0.38</td>
</tr>
<tr>
<td>Feather %</td>
<td>9.03 ±0.27</td>
<td>7.98 ±0.69</td>
<td>8.61 ±0.96</td>
<td>8.33 ±0.77</td>
<td>8.43 ±0.81</td>
<td>8.42 ±0.75</td>
<td>8.09 ±1.18</td>
<td>8.74 ±0.93</td>
<td>7.78 ±1.03</td>
<td>8.78 ±0.68</td>
<td>7.79 ±0.88</td>
<td>7.73 ±1.06</td>
<td>8.59 ±0.58</td>
</tr>
<tr>
<td>Head %</td>
<td>2.83 ±0.25</td>
<td>2.70 ±0.12</td>
<td>2.97 ±0.20</td>
<td>2.77 ±0.18</td>
<td>2.97 ±0.12</td>
<td>2.98 ±0.14</td>
<td>2.72 ±0.24</td>
<td>2.96 ±0.16</td>
<td>2.77 ±0.25</td>
<td>3.01 ±0.04</td>
<td>2.81 ±0.20</td>
<td>2.78 ±0.25</td>
<td>3.04 ±0.29</td>
</tr>
<tr>
<td>Appendages %</td>
<td>4.75 ±0.38</td>
<td>4.87 ±0.19</td>
<td>5.00 ±0.16</td>
<td>4.87 ±0.13</td>
<td>4.86 ±0.15</td>
<td>4.83 ±0.18</td>
<td>4.71 ±0.24</td>
<td>5.05 ±0.10</td>
<td>4.81 ±0.19</td>
<td>5.06 ±0.07</td>
<td>4.89 ±0.14</td>
<td>4.83 ±0.27</td>
<td>5.00 ±0.24</td>
</tr>
<tr>
<td>Separable fat%</td>
<td>1.51 ±0.01</td>
<td>1.46 ±0.10</td>
<td>1.52 ±0.06</td>
<td>1.50 ±0.07</td>
<td>1.48 ±0.05</td>
<td>1.53 ±0.03</td>
<td>1.45 ±0.12</td>
<td>1.44 ±0.10</td>
<td>1.41 ±0.05</td>
<td>1.55 ±0.01</td>
<td>1.46 ±0.06</td>
<td>1.47 ±0.13</td>
<td>1.46 ±0.09</td>
</tr>
<tr>
<td>Total Processing loss%</td>
<td>21.24 ±0.87</td>
<td>20.03 ±1.26</td>
<td>21.01 ±1.57</td>
<td>20.55 ±1.15</td>
<td>20.85 ±1.02</td>
<td>21.01 ±1.01</td>
<td>19.72 ±1.98</td>
<td>21.32 ±1.65</td>
<td>19.66 ±0.73</td>
<td>21.56 ±0.73</td>
<td>20.01 ±1.30</td>
<td>19.72 ±1.26</td>
<td>20.99 ±2.07</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
4.4 Effect of organic acid salts supplementation on humoral immune response of broilers (30th and 42nd day)

The effect of different organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) supplementation on humoral immune response in terms of Haemagglutination titre of broilers was estimated on 30th and 42nd day.

Birds from all groups in the 14 treatments were administered the NDV vaccine on the 7th and 21st day by the ocular and oral route, respectively.

In the present study treatment means of haemagglutination inhibition titre on 30th and 42nd day indicated that supplementation of organic acid salts in the diets of broilers influenced their immune response as presented below in Table 11 and Fig 09.

Table 11: Mean values of Haemagglutination inhibition test (HI) in broilers in different treatment groups (30th and 42nd day)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>30th</th>
<th>42nd</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>2.4083±0.12</td>
<td>2.7092±0.06</td>
</tr>
<tr>
<td>T2</td>
<td>2.7081±0.02</td>
<td>2.7092±0.06</td>
</tr>
<tr>
<td>T3</td>
<td>3.1120±0.01</td>
<td>3.0100±0.08</td>
</tr>
<tr>
<td>T4</td>
<td>2.7092±0.01</td>
<td>2.6011±0.09</td>
</tr>
<tr>
<td>T5</td>
<td>3.0100±0.01</td>
<td>3.3113±0.06</td>
</tr>
<tr>
<td>T6</td>
<td>1.5051±0.06</td>
<td>1.2041±0.08</td>
</tr>
<tr>
<td>T7</td>
<td>3.0100±0.08</td>
<td>3.0100±0.08</td>
</tr>
<tr>
<td>T8</td>
<td>4.3640±0.12</td>
<td>4.4720±0.03</td>
</tr>
<tr>
<td>T9</td>
<td>3.3112±0.17</td>
<td>3.2158±0.11</td>
</tr>
<tr>
<td>T10</td>
<td>4.1010±0.06</td>
<td>4.3640±0.13</td>
</tr>
<tr>
<td>T11</td>
<td>1.2041±0.06</td>
<td>1.3042±0.12</td>
</tr>
<tr>
<td>T12</td>
<td>3.6120±0.20</td>
<td>3.8123±0.06</td>
</tr>
<tr>
<td>T13</td>
<td>4.3640±0.13</td>
<td>4.6637±0.08</td>
</tr>
<tr>
<td>T14</td>
<td>4.3640±0.13</td>
<td>4.3640±0.13</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
Among organic acid salts supplemented diets, haemagglutination inhibition (HI) titre on 30\textsuperscript{th} and 42\textsuperscript{nd} day were influenced by the lower level of supplementation (2\%). Humoral immune response in birds fed on diets T3 (3.1120±0.01 and 3.0100±0.08) and T5 (3.0100±0.01 and 3.3113±0.06) were found significantly higher (P<0.05) when compared with the control. Further, HI titre in birds fed on diets T2 (2.7081±0.02 and 2.7092±0.06) and T4 (2.7092±0.01 and 2.6011±0.09) were found statistically similar (P>0.05) when compared with the control. Minimum and significantly (P<0.05) lower HI titre was observed in broilers assigned T6 (1.5051±0.06 and 1.2041±0.08) diet.

Use of higher levels of organic acid salts supplementation (3\%) tends to improve the HI titre on 30\textsuperscript{th} and 42\textsuperscript{nd} day in broilers. Maximum and significantly (P<0.05) higher HI titre was noted in broilers fed on T8 (4.3640±0.12 and 4.4720±0.03) diet. Further, HI titre in birds fed on diets T7 (3.0100±0.08 and 3.0100±0.08), T9 (3.3112±0.17 and 3.2158±0.11) and T10 (4.1010±0.06 and 4.3640±0.13) were found statistically (P>0.05) similar but significantly (P<0.05) higher when compared with the control. Minimum and significantly (P<0.05) lower HI titre was observed in broilers assigned T11 (1.2041±0.06 and 1.3042±0.12) diet.

Similarly, different feed additives other than organic acid salts, combination of prebiotic and probiotic (synbiotic) and antibiotic growth promoter improved the immune response in broilers on 30\textsuperscript{th} and 42\textsuperscript{nd} day.

Experimental groups supplemented with synbiotic and antibiotic growth promoter showed higher HI titre on 30\textsuperscript{th} and 42\textsuperscript{nd} day. Average values for HI titre of broilers on 30\textsuperscript{th} and 42\textsuperscript{nd} day were T12 (3.6120±0.20 and 3.8123±0.06), T13 (4.3640±0.13 and 4.6637±0.08) and T14 (4.3640±0.13 and 4.3640±0.13), respectively. Therefore, broilers fed on diets supplemented with probiotic, synbiotic and antibiotic growth promoter significantly (P<0.05) improved the HI titre in broilers on 30\textsuperscript{th} and 42\textsuperscript{nd} day when compared to control.
4.5 Effect of organic acid salts supplementation on caecal bacterial count of broilers (42\textsuperscript{nd} day)

The effect of different organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) supplementation on caecal bacterial count of broilers was estimated on 42\textsuperscript{nd} day as presented below in Table 12 and Fig 10.

Table 12: Mean values of caecal bacterial count (log10 cfu/g) in broilers in different treatment groups (42\textsuperscript{nd} day)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>42\textsuperscript{nd}</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>16.36\textsuperscript{a}±0.16</td>
</tr>
<tr>
<td>T2</td>
<td>15.72\textsuperscript{b}±0.19</td>
</tr>
<tr>
<td>T3</td>
<td>15.67\textsuperscript{b}±0.22</td>
</tr>
<tr>
<td>T4</td>
<td>15.71\textsuperscript{b}±0.14</td>
</tr>
<tr>
<td>T5</td>
<td>15.69\textsuperscript{b}±0.23</td>
</tr>
<tr>
<td>T6</td>
<td>15.91\textsuperscript{ab}±0.23</td>
</tr>
<tr>
<td>T7</td>
<td>15.69\textsuperscript{b}±0.16</td>
</tr>
<tr>
<td>T8</td>
<td>15.40\textsuperscript{bc}±0.18</td>
</tr>
<tr>
<td>T9</td>
<td>15.43\textsuperscript{bc}±0.20</td>
</tr>
<tr>
<td>T10</td>
<td>15.47\textsuperscript{bc}±0.14</td>
</tr>
<tr>
<td>T11</td>
<td>15.88\textsuperscript{ab}±0.12</td>
</tr>
<tr>
<td>T12</td>
<td>15.99\textsuperscript{ab}±0.25</td>
</tr>
<tr>
<td>T13</td>
<td>15.84\textsuperscript{ab}±0.13</td>
</tr>
<tr>
<td>T14</td>
<td>12.30\textsuperscript{c}±0.11</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)

Among organic acid salts supplemented diets, caecal bacterial count were influenced by the lower level of supplementation (2%), therefore, caecal bacterial count in birds fed on diets T2 (15.72±0.19) T3 (15.67±0.22) T4 (15.71±0.14) and T5 (15.69±0.23) were found statistically (P>0.05) similar but when compared to control they were significantly (P>0.05) lower. Maximum and significantly (P<0.05) higher caecal bacterial count was observed in broilers assigned T6 (15.91±0.23) diet.
Use of higher levels of organic acid salts supplementation (3%) tends to improve the caecal bacterial count in broilers. Minimum and significantly (P>0.05) lower caecal bacterial count was noted in broilers fed on T7 diet (15.69±0.16), T8 diet (15.40±0.18) T9 diet (15.43±0.20) and T10 (15.47±0.14). When compared with the control T1 (16.36±0.16). Maximum and significantly (P<0.05) higher caecal bacterial count was observed in broilers assigned T11 (15.88±0.12) diet.

Similarly, different feed additives other than organic acid salts, combination of prebiotic and probiotic (synbiotics) and antibiotic growth promoter improved the caecal bacterial count in broilers.

Experimental groups supplemented with antibiotic growth promoter showed better caecal bacterial count. Average values for caecal bacterial count of broilers fed on diets T14 (12.30±0.11). Therefore, broilers fed on diet supplemented with antibiotic growth promoter significantly (P<0.05) improved the caecal bacterial count when compared to control. However, caecal bacterial count in broilers fed on diets supplemented with probiotic T12 (15.99±0.25) and synbiotic T13 (15.84±0.13) was statistically similar (P> 0.05) to those assigned control diet T1 (16.36±0.16).

4.4 Effect of organic acid salts supplementation on economics of broiler productions.

The effect of different organic acid salts (sodium acetate, calcium sorbate calcium propionate, sodium butyrate and sodium lactate) supplementation on economics of broiler productions are presented below in Table 13 and Fig 11.

Among organic acid salt supplemented diets, feed cost/kg body weight gain did not influenced by supplementation of organic acids at lower level (2%), however, significantly lower (P>0.05) feed cost/kg body weight gain was found in broilers fed on T3 diet (44.43±0.09) which was statistically similar to control (43.87±0.09). Significantly higher feed cost/kg body weight gain was observed in broilers fed on T2 (45.68±0.24), T4 (45.95±0.05) and T5 (45.71±0.04) diets when compared to control, however, they were statistically similar (P>0.05). Maximum and significantly (P<0.05) higher feed cost/kg body weight gain was observed in broilers assigned T6 (50.49±0.18) diet.
Table 13: Economics of feeding of broilers in different treatment groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control Diet</th>
<th>Sodium acetate (2%)</th>
<th>Calcium sorbate (2%)</th>
<th>Calcium propionate (2%)</th>
<th>Sodium butyrate (2%)</th>
<th>Sodium acetate (3%)</th>
<th>Calcium sorbate (3%)</th>
<th>Calcium propionate (3%)</th>
<th>Sodium butyrate (3%)</th>
<th>Sodium lactate (3%)</th>
<th>Probiotic</th>
<th>Synbiotics</th>
<th>BMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed cost /kg (Rs)</td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
<td>T4</td>
<td>T5</td>
<td>T6</td>
<td>T7</td>
<td>T8</td>
<td>T9</td>
<td>T10</td>
<td>T11</td>
<td>T12</td>
<td>T13</td>
</tr>
<tr>
<td>Feed cost /kg body weight gain</td>
<td>43.87±0.09</td>
<td>45.68±0.24</td>
<td>44.43±0.09</td>
<td>45.95±0.05</td>
<td>45.71±0.04</td>
<td>50.49±0.18</td>
<td>45.93±0.04</td>
<td>42.19±0.08</td>
<td>45.56±0.07</td>
<td>45.28±0.04</td>
<td>54.08±0.87</td>
<td>44.28±0.05</td>
<td>40.86±0.05</td>
</tr>
<tr>
<td></td>
<td>43.87±0.09</td>
<td>45.68±0.24</td>
<td>44.43±0.09</td>
<td>45.95±0.05</td>
<td>45.71±0.04</td>
<td>50.49±0.18</td>
<td>45.93±0.04</td>
<td>42.19±0.08</td>
<td>45.56±0.07</td>
<td>45.28±0.04</td>
<td>54.08±0.87</td>
<td>44.28±0.05</td>
<td>40.86±0.05</td>
</tr>
</tbody>
</table>

Means of row with different superscript showing significant difference at (P<0.05)
Supplementation of organic acid salts at higher levels (3%) improved the feed cost/kg body weight gain in broilers. Significantly lowest (P>0.05) feed cost/kg body weight gain was observed in broilers fed on T8 (42.19±0.08) diet when compared with the control T1 (43.87±0.09). Significantly higher feed cost/kg body weight gain was observed in broilers fed on T7 (45.93±0.04), T9 (45.56±0.07) and T10 (45.28±0.04) diets when compared to control, however, they were statistically similar (P>0.05). Maximum and significantly (P<0.05) higher feed cost/kg body weight gain was observed in broilers assigned T11 (54.08 ±0.87) diet.

Similarly, different feed additives other than organic acid salts, combination of prebiotic and probiotic (synbiotic) and antibiotic growth promoter improved the economics of broilers.

Experimental groups supplemented with synbiotic T13 (40.86±0.06) and antibiotic growth promoter T14 (40.17±0.10) diet showed significantly lower (P<0.05) feed cost per kg body weight gain when compared to control T1 (43.87±0.09), except T12 (44.28±0.05) diet which was found statistically similar to control T1 (43.87±0.09).
5. DISCUSSION

Now a day, broiler poultry industry tends to use the alternative growth promoter to replace antibiotics to avoid its adverse effect on public health (Hertrampf, 2001). Although the available literature does not provide us clear cut result, the previous results of growth promoter in diets of broiler were different. Therefore, our study aims to explore the effects of dietary supplementation of Organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate), Probiotic (Saccharomyces boulardii), Synbiotic (Saccharomyces boulardii + MOS) and antibiotic (Bacitracin Methylene Disalicylate) as growth promoter on broiler’s performance.

5.1 Performance of broilers

5.1.1 Effect of organic acid salts/ probiotic/ synbiotic/ antibiotic growth promoter supplementation on overall performance of broilers (0-42d)

**Body weight and weight gain**

In the present study, among organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) supplemented diets, inclusion of lower level of organic acids (2%) did not influence (P>0.05) the average total body weight and weight gain in broilers. Therefore, average total body weight in broilers fed on 2% sodium acetate, calcium sorbate, calcium propionate, sodium butyrate supplemented diets were found statistically (P>0.05) similar to those fed on control diet. The decreased growth response observed due to inclusion of lower levels of organic acids in this study is in agreement with the results reported by Woo et al. (2006), Biggs and Parsons, 2008 and Woyengo et al., 2010.

Further in our study, increase in the level of calcium sorbate and sodium butyrate from 2 to 3% in diet of broilers significantly (P<0.05) increases their overall body weight as well as weight gain. Maximum and significantly (P<0.05) higher overall body weight and weight gain was noted in broilers fed on 3% calcium sorbate. Whereas, total body weight and weight gain in broilers fed on 3% sodium acetate and calcium propionate
supplemented diets were found statistically (P>0.05) similar to those fed on control diet. However, minimum and significantly (P<0.05) lower total body weight and gain was observed in broilers assigned 2% and 3% sodium lactate diet. Our results clearly showed that the organic acid (3% calcium sorbate and sodium butyrate) have stimulated the growth of broilers during the entire experimental period. Similar, increased growth response were reported by Nourmohammadi et al. (2012), Sohail et al. (2015), Kamel and Mohamed (2016), Alsultan Bagal, and Rout, et al. (2016) and Ndelekwute and Enyenihi (2017), they found that supplementation of organic acids to the basal diet improved broiler performance as compared with those fed un-supplemented diets. Improvement in the body weight gain recorded in the present study could be attributed to the direct antimicrobial effect of organic acids which might have resulted in inhibition of intestinal bacteria leading to the reduced bacterial competition with the host for available nutrients and reduction in the level of toxic bacterial metabolites as a result of lessened bacterial fermentation resulting in the improvement of protein and energy digestibility, thereby improving the weight gain of broiler chicken (Adil et al, 2011 ).

Organic acid supplementation reduces the growth of many pathogenic and non-pathogenic intestinal bacteria due to reduction in intestinal colonization and infectious process. Similarly, in the present study, experimental groups supplemented with synbiotic (Saccharomyces boulardii + MOS) showed significantly (P<0.05) higher overall body weight gain. Our results clearly showed that synbiotics stimulated the growth of broilers during the entire experimental period. Improvement in growth performance in broilers chickens fed synbiotic may be attributed to the combined effect of prebiotic and probiotic action including the maintenance of beneficial microbial population (Fuller, 1989), improving digestion (Nahanshon et al., 1992) and altering bacterial metabolism. The results of our study are supported by other studies (Li et al., 2007; Mountzouris et al., 2007 and Awad et al., 2008, 2009). These studies reported that synbiotics could enhance the performance of broilers by (1) improving intestinal morphology and microbial balance associated with suppressing intestinal pathogens, by competitive exclusion and antagonism,
such as *Salmonella*, *Campylobacter* and *E. coli* (Kabir *et al*., 2005), (2) increasing digestive enzyme activity and decreasing bacterial enzyme activity and ammonia production (Jin *et al*., 2000), (3) also by an increase in the uptake of nutrients (fatty acids and glucose), (4) fixation of nitrogen and reduction of excretion of fat in feces and microbial urea (Willis *et al*., 2008), (5) Stimulating the immune system and reducing mortality (Kabir, 2009). Therefore, beneficial effect of synbiotic supplement in the gastrointestinal tract could result in an improvement of overall health and performance of birds.

In the present study, experimental groups supplemented with antibiotic growth promoter (Bacitracin Methylene Disalicylate) showed significantly (P<0.05) higher overall body weight gain. The growth-promoting effects of antibiotic are closely related to their inhibitory effect on pathogenic microbes in the GI tract. Reduction in the population of intestinal harmful microflora have several beneficial effects, including a reduction in the incidence of sub-clinical diseases (thus results in reducing nutritional costs of the immune mechanisms), reduction in the quantity of growth depressing metabolites produced by intestinal microbes, a reduction in the competition between microbes and hosts for available nutrients, and improve nutrient uptake by absorptive cells of the gut (Niewold, 2007). Our results are in agreement with the results reported by Engberg *et al*. (2000) and Amerah *et al*. (2013) who also found significantly improved broiler performance on BMD supplemented diets. Similarly, Singh *et al*. (2008) also reported that dietary inclusion of both Bacitracin Methylene Disalicylate (BMD) and Virginiamycin significantly increased (P<0.01) the body weight gains in broilers.

The results of our study clearly showed that the supplementation of probiotics alone did not significantly affect the body weight gain in broilers but when combined with prebiotic (synbiotic) stimulated the growth of broilers during the entire experimental period. Similarly, Angel *et al*. (2005) also reported that under favorable rearing conditions, without disease or stress, dietary supplementation of probiotic had no beneficial effects on broiler growth performance. Karaoglu and Durdag (2005) used *Saccharomyces cerevisiae* as a dietary probiotic to assess the performance of broilers and found no overall weight gain difference. Our results are also in agreement with Dizaji *et
al. (2012) who found no significant effect of probiotic supplementation on body weight gain in broilers which could be due to differences in strain of microorganisms, level of application, feeding conditions, weather, stress etc.

Feed intake

The overall results on total feed intake of present study in broilers indicated that feed intake was not influenced (P>0.05) by dietary supplementation of 2 and 3% organic acids (sodium acetate, calcium sorbate, calcium propionate and sodium butyrate) when compared with the control. No effect on feed consumption as observed in our study is in agreement with the results reported by Adil et al. (2011) who reported that supplementation of acidifier alone did not influence feed consumption in chickens. Fumaric acid significantly increases the BWG at the rate of 0.5% and 1.0% without affecting feed intake in broilers and layers (Skinner et al., 1991). Similarly, Alcicek et al., (2004) also reported that dietary supplementation of the organic acid does not affect the feed intake and FCR at 21 and 42 day of age in broilers. In contrary to our result, significant increase in feed intake following acidifier supplementation in broilers was reported by Ogunwole et al. (2011).

In our study, supplementation of probiotic alone did not influence feed consumption in chickens. The results corroborated with those of previous workers (Dizaji et al., 2012; and Datt et al., 2013), who found that probiotics supplementation had no effect on feed consumption.

Present study in broilers indicated that the total feed intake was not influenced (P>0.05) by dietary supplementation synbiotic and antibiotic growth promoter when compared with the control. The present finding was in agreement with Jung et al. (2008) who found that addition of prebiotic and probiotic did not have any significant effect on feed intake of broiler chickens. However, the present observation was found not in concurrence with the result of Salianeh et al. (2011), who reported that dietary inclusion of prebiotic significantly decreased feed intake in broiler chickens as compared to control group, whereas addition of probiotic did not have the same effect as prebiotic. Similarly, Amerah et al. (2013) observed that BMD addition to the basal diets in broilers had no effect on their feed consumption.
Feed Conversion Ratio

Results on feed conversion ratio of present study in broilers indicated that feed conversion ratio was significantly improved (P<0.05) by dietary supplementation of 3% organic acids (calcium sorbate, sodium butyrate, sodium acetate and calcium propionate) when compared with the control. Among different organic acid supplementation at 2 or 3% levels in basal diet, significantly better feed efficiency (P<0.05) was noted in broilers fed on 3% calcium sorbate. These results were in concordance with the reports of previous researchers. Likewise Paul et al. (2007) also reported that broiler chickens fed diets supplemented with calcium propionate @ 3 g/kg had significantly improved feed efficiency by 6.5% compared with those fed control diets. Al-Kassi and Mohssen (2009) reported that adding 2 g/kg of propionic acid to broiler diets resulted in significant improvements in body weight gain, feed intake, and feed efficiency by 11.2, 5.1, and 6.1%, respectively.

Similarly, Kim et al. (2009) also reported that body weight gain in acid blend-supplemented groups was increased from 1.8 to 3.2%, whereas feed efficiency was improved by nearly 4.0%. The results obtained are also in line with earlier reports (Sohail et al., 2015; Bagal et al., 2016; Kamel and Mohamed 2016; Al sultan et al., 2016; Rout et al., 2016 and Ndelekwute and Enyenihi, 2017), who showed improvement in feed conversion ratio by supplementation of acidifiers alone. The improved feed efficiency by supplementation of acidifiers in broilers may be well attributed to increased digestibility of nutrients induced by favorable gut conditions including decreased pH of digesta in different segment, improved gut size and morphometry, which accounts for increased absorption surface.

Similarly, results on feed conversion ratio of present study in broilers indicated that feed conversion ratio was significantly improved (P<0.05) by dietary supplementation of synbiotic and antibiotic growth promoter. The consumption of a probiotic in combination with a suitable prebiotic (synbiotic) can result in synergistic effects which improves the functions and shelf life of probiotic (Zanoni et al., 2008). Synbiotic products contain viable beneficial bacterial cultures that establish early in the gut while the prebiotic present in them serve as a source of nutrient for the probiotics in
addition to dietary sources (Mohnl et al., 2007). Therefore, combination of a pre- and probiotic in one product has been shown to confer benefits beyond those of either on its own. Our results are in accordance with the reports of previous researchers. Mohnl et al. (2007) found that the synbiotic had a comparable potential to improve broiler feed efficiency as avilamycin (an antibiotic growth promoter). Similarly, Awad et al. (2009) reported beneficial effects of a synbiotic over a probiotic on broiler performance and feed efficiency. Elijah and Ruth (2012) concluded that synergistic effects of prebiotics and probiotics can be useful in stimulating beneficial bacteria and improving the health of the gut. Razek and Tony (2012) concluded that mixtures of synbiotics and digestive enzymes act synergistically as feed additives and reflected positively on feed conversion efficiency of broiler chickens, reduce stresses and enhance immune status. Abudabos and Murshed (2015) also reported best FCR in broilers fed diets with antibiotic growth promoter.

5.2 Effect of organic acid salts/ probiotic/ synbiotic/ antibiotic growth promoter supplementation on nutrient utilization in broilers

In the present study, among organic acid salts supplemented diets, digestibility of dry matter, crude protein and gross energy were not influenced at lower level (2%), but inclusion at higher level (3%) improved their digestibilities. Maximum and significantly (P<0.05) higher DM, CP and GE digestibility was noted in broilers fed on diet supplemented with 3% calcium sorbate.

Broilers fed on diets supplemented with organic acid salts increased digestibility of DM, CP and AME as well as other nutrients induced by favorable gut conditions including decreased pH of digesta in different segment, improved gut size and morphometry, which accounts for increased absorption surface. However, it is postulated that improved digestibility may also in part be associated with increased zymogen activation (Salgado-Transito et al., 2011) and protease secretion by elevated acidity in gut lumen following enhanced gastrin and cholecystokinin hormones release which regulate the digestion and absorption of proteins (Biggs and Parsons, 2008). The results of present study are in agreement with the reports of previous
researchers. Son et al. (2002) also indicated that addition of OA to the broilers diet slowed the passage rate of feed through the gastro-intestinal tract and that the raised digestion time improved the digestibility of nutrients in broiler chickens. Hassan et al. (2015) concluded that addition of organic acids mixture improved the digestibility coefficients (P<0.01) of DM, OM, CP, CF and NFE compared to the un-supplemented diet in broiler chicks. Ghazalah et al. (2011) compare the effects of different types and levels of organic acids Formic (0.25, 0.5 and 1.0%), Fumaric (0.5, 1.0 and 1.5%), Acetic (0.25, 0.50 and 0.75%) and Citric Acids (1, 2 and 3%) in broilers diet and observed that organic acids improved both ME and nutrients digestibility (CP, EE and NFE). Similarly, Nourmohammadi et al. (2012) pointed out that the addition of OA to broiler chicken diets increased AME digestibility. The present finding were also in agreement with Khosravinia et al. (2015) who reported that supplementation of acidifier (30 g/kg of citric acid) to the diet improved nutrient retention (Ileal digestibility of crude protein, apparent metabolizable energy and total phosphorus) in broiler chicken.

Similarly, in our study, other than organic acid salts supplemented groups, experimental groups supplemented with synbiotic showed better and significantly (P<0.05) higher dry matter, crude protein and gross energy digestibility. However, DM, CP and GE digestibility in broilers fed on diet supplemented with probiotic was statistically similar (P> 0.05) to those assigned control diet. Prebiotics, probiotics and their synergistic effect could reduce the count of pathogenic bacteria and increase the population of useful microflora in gut (Rada et al., 1995). Thus, it can be presumed that by removing pathogenic bacteria adhered to the gastrointestinal tract wall, immune system may be less stimulated and a favorable medium created for better use of energy and nutrients by birds (Ashayerizadeh et al., 2011). Furthermore, the effect of probiotics and prebiotics on reduction of pathogenic bacteria could reduce the breakdown of proteins to nitrogen in GIT and hence, improves the utilization of proteins (amino acids). Thus, each above process as individual way or collectively is found to be responsible for better performance of broiler birds supplemented with synbiotic. Also, the use of prebiotics increases the length of the intestinal villi, thus, increases the
absorption area and improves the bird’s energy and protein efficiency ratio (Santin et al., 2001). The present finding was in agreement with Fernandez et al. (1973) and Edgar and Flanagan (1979) who also reported that total body weight, body weight gain and efficiency of feed utilization of birds supplemented with synbiotic were superior to control.

In present study experimental groups supplemented with antibiotic growth promoter (BMD) showed better and significantly (P<0.05) higher retention of dry matter, crude protein and gross energy. Similarly, Dash et al., (1992) also observed better feed conversion efficiency and feed utilization with virginiamycin supplemented diets in broilers.

5.3 Carcass traits in broilers fed diet supplemented with organic acid salts/probiotic/synbiotic/antibiotic growth promoter

Carcass traits were not significantly influenced in broilers fed on diets supplemented with organic acid salts, probiotic, synbiotic and antibiotic growth promoter, therefore, % carcass yield in terms of dressed weight, eviscerated weight and drawn weight in broilers fed different dietary treatments were found statistically (P>0.05) similar in comparison to unsupplemented diet. However, no significant differences were detected on organ weights like heart, liver, gizzard, spleen and pancreas (% body weight) among treatments. Similarly, dietary treatments had no significant effect on processing losses in the present study. Thus, supplementation of organic acids at 2 or 3% levels had no negative effect on carcass characteristics of broilers examined in this study. The effects of feed additives used in this study were associated with growth stimulation, enhanced nutrient digestion and absorption, though this enhancement was not converted to carcass yield. The present findings were in agreement with Zhang et al. (2005) who found no significant effect on the carcass yield of broiler fed dietary acidifier. Similar observations were reported by Alcicek et al. (2004) for probiotics and by Waldroup et al. (2003), Bozkurt et al. (2005), for prebiotics.

Likewise, Jin et al. (1998) found that dietary prebiotic and probiotic supplementation, did not stimulate the heart, liver, gizzard weights of broilers. Dietary treatments had no significant effect on abdominal fat pad
accumulation in the present study. Similar results were observed by researchers who studied supplementation of prebiotics (Waldroup et al., 2003a; b and Bozkurt et al., 2005), organic acids (Izat et al., 1990b; Skinner et al., 1991) and probiotics (Denli et al., 2003; Alcicek et al., 2004) to broiler diets. The present finding was also in agreement with Ogunwole et al. (2011) who reported no significant difference (P>0.05) in liver weight and heart weight of broilers treated with dietary acidifiers. Similar observations were also reported by Dizaji et al. (2012) who conducted trial to investigate the effects of dietary supplementations of prebiotic, probiotic, synbiotic and acidifier on organ's weight of broiler chickens and they found that weight of proventriculus, gizzard, liver, and bursa did not differ (P>0.05) between groups.

5.4 Effect of organic acid salts/ probiotic/ synbiotic/ antibiotic growth promoter on humoral immune response

Results on humoral immune response in terms of haemagglutination titer of present study in broilers indicated that humoral immune response was significantly improved (P<0.05) by dietary supplementation of 3% organic acids (calcium sorbate, sodium butyrate, sodium acetate and calcium propionate) when compared with the control. Significantly (P<0.05) increased antibody titer against Newcastle disease was noted in broilers fed on 3% calcium sorbate and sodium butyrate. Dietary OA play an important contributory role in the immune status of the bird. Reduction of subclinical infections (Humphrey and Lanning, 1988) and stimulation of the growth of beneficial bacteria contribute to increased nutrient digestibility and a reduction in nutrient demand by the gut-associated immune tissue and microorganisms (Dibner and Buttin, 2002). Organic acids also enhances the bioavailability of different minerals like Zn (Boling et al., 2000), Fe, Ca, and P, which are important to immunity (Rafacz-Livingston et al., 2005). Organic acid supplementation causes hyperthyroidism and peripheral conversion of thyroxin (T4) to triiodothyronine (T3) which showed that these birds have better immune competence and bursa growth (Abdel-Fattah et al., 2008). Citric acid supplementation enhances the density of lymphocytes in the lymphoid organs, thus, enhances the non-specific immunity (Chowdhury et
al., 2009 and Haque et al., 2010). The present findings were in agreement with Das et al. (2011), Houshmand et al. (2012) and Al sultan et al. (2016), who reported an increased antibody titer against Newcastle disease in broilers by dietary supplementation of organic acids.

The results of the present study showed that broilers fed on diets supplemented with probiotic and synbiotic significantly (P<0.05) improved the HI titre in broilers on 30th and 42nd day when compared to control. These additives improve feed efficiency by improving intestinal microflora population, intestinal integrity and stimulating appetite as well as stimulating the immune system. These results are in agreement with that of Maassen et al. (2000) who recorded that, oral administration of lactobacillus strain is significantly enhance IgG response. Similarly, Haghighi et al. (2006) found that probiotics enhances the systemic antibody response to some antigens in chickens. Ghahri, et al. (2013) and Razek and Tony (2013) also examined the effect of the synbiotic on humoral immune response in broiler chickens and concluded that synbiotic supplementation improved the HI antibody titers for Newcastle Disease Virus (NDV) and ELISA antibody for Gumboro disease (IBV) comparing with that of control group. The present finding was in agreement with Al-Sultan et al. (2016) who investigated that synbiotic followed by probiotic supplemented groups revealed the highest antibody response to Newcastle disease vaccine (NDV) in comparison with prebiotic and organic acids.

Results of the present study also showed that broilers fed on diets supplemented with antibiotic growth promoter (BMD) significantly (P<0.05) improved the HI titre in broilers on 30th and 42nd day when compared to control. However, these effects were not reported by Khovidhunkit et al. (2004) who showed that antibiotics restrain gram-positive bacteria that stimulate the immune system. Hence, diminished antibody titration by use of antibiotic was confirmed by the results of his study.

5.5 Effect of organic acid salts/ probiotic/ synbiotic/ antibiotic growth promoter on Intestinal microbial population

In the present study, among organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate)
supplemented diets, inclusion of 2 and 3% levels of organic acids significantly (P>0.05) lower caecal bacterial count when compared to control. The order of bactericidal activities of different organic acids salts used in our study were as follows from higher to lower order: calcium sorbate > sodium butyrate > calcium propionate > sodium acetate > sodium lactate. Major objective of the dietary acidification in poultry is to reduce the pathogenic bacteria (Griggs and Jacob, 2005) or increase beneficial bacteria number, both in the feed and by influencing the gut or intestinal environment (Ewing, 2009), so as to support enteric health and growth performance. Most common bacteria that affect the intestinal health of poultry are *Salmonella, Escherichia coli* (*E. coli*), *Clostridium*, etc. Though a very small effect but these bacteria compete with the host for the nutrients and produce different types of metabolites like ammonia and amines, possibly a result of amino acid deamination, hence leading to reduced growth of the poultry birds. So, by reducing the number of these bacteria, growth rate gets enhanced. Organic acid reduces *E. coli, Campylobacter* and *Salmonella* challenges in poultry (Heres *et al.*, 2004). Acid-intolerant species such as *E. coli, Campylobacter* and *Salmonella* families are particularly affected by the actions of organic acids (Al-Kassi and Mohssen, 2009). Hinton *et al.* (2000) reported that low pH and higher number of *lactobacilli* lower the incidence of the *Salmonella* in crop of broiler chicks. A mixture of organic acids significantly lowers the total bacterial count especially gram negative bacteria in broilers (Gunal *et al.*, 2006). The RCOO– anion produced from organic acids can hinder bacterial genetic regulation i.e., DNA and protein synthesis. Van Immerseel *et al.* (2006) reported that at low dose butyric acid can suppress genes responsible for the *Salmonella* invasion. Our results find support with earlier scientists Ghazalah *et al.* (2011) and Mohamed *et al.* (2014) who reported that addition of organic acids to the diets of broiler chicken significantly decreased (P<0.05) the caecal viable coliform counts compared to the un-supplemented group.

Similarly in present study antibiotic growth promoter (BMD) reduced the caecal bacterial count in broilers. However, diets supplemented with probiotic and synbiotic did not influence (P>0.05) the caecal bacterial count in broilers. The present finding was in agreement with Singh, *et al.*
(2008) who reported that dietary supplementation of Bacitracin Methylene Disalicylate @150 g and 200 g/MT and Virginiamycin @500g/MT in broiler diets reduced total caecal bacterial population. Further, our results find support with earlier scientist Abdel-Raheem and Abd-Allah (2012) who investigated the effects of dietary supplementation of prebiotic (MOS), Probiotic (Saccharomyces cerevisiae) and their combination (synbiotic) on intestinal microflora of broilers and observed that the total caecal bacterial counts were not significantly affected by any of the dietary treatment. However, Al-Sultan et al. (2016) reported that synbiotic followed by probiotic supplementation significantly improved intestinal microbial ecology than prebiotic, organic acids and control groups. Fuller, (1989) suggested that a density of CFU/g of Lactobacillus can effectively suppress other bacteria in the GI tract due to decreased lumen pH from the production of lactic acid and at the same time, the prebiotic mannanoligosaccharides not only prevent those pathogenic bacteria possessing type-1 fimbriae, such as E. coli, from attaching to gut wall but also displace them from the gut wall. Dietary prebiotics, probiotic, synbiotic change intestinal microbial community towards beneficial bacteria which play an important role in the prevention of colonization by pathogens in the gastrointestinal tract of chickens through a process known as competitive exclusion.

5.6 Economics of production in broilers fed diet supplemented with organic acid salts/ probiotic/ synbiotic/ antibiotic growth promoter

In present study, among organic acid salts supplemented diets, lowest feed cost per kg live weight gain for total period was observed in broilers fed on 3% calcium sorbate diet. It might be due to better FCR and higher nutrient retention in this group. Further, different feed additives other than organic acid salts, including combination of prebiotic and probiotic (synbiotics) and antibiotic growth promoter improved the economics of broilers. Under present experimental condition, synbiotic and antibiotic growth promoter appeared to be economical compared to organic acids supplemented diet in terms of feed cost per kg live weight gain. Our finding
was in agreement with Narasimha et al. (2015) also reported that supplementing broiler diets with NSP enzymes along with synbiotics reduces cost of production compared to unsupplemented control. The findings of present study was in agreement with Kamel and Mohamed (2016) who conducted study to evaluate the effect of different feed additives (Probiotics, Prebiotic, Synbiotic, Organic acids and Enzymes) on productive and economic efficiency of broiler chicken. They reported that value of total return was highest for organic acid supplemented groups and for synbiotic, while the lowest value was found for the enzyme group. Thus in our study net profit among various organic acid supplemented diets was highest in broilers fed on diet supplemented with 3% calcium sorbate diet.
6. SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

A study was conducted to investigate the effect of dietary supplementation of different organic acid salts, an antibiotic growth promoter and probiotic alone or the probiotic combined with the prebiotic on the performance, nutrient utilization, carcass traits, immune response and economical production of broiler chickens fed with corn-soya diet. Two hundred and fifty two, day old Cobb commercial broiler chicks were randomly distributed into 14 experimental groups, each group consisted of 3 replicates and 6 chicks per replicate. The standard broiler diets (T1) were formulated as per BIS (2007) specifications. There were total 14 dietary treatments. In the control group, birds were fed diets without any organic acid salts (T1) while same diet of experimental groups were supplemented with 2% sodium acetate (T2), 2% calcium sorbate (T3), 2% calcium propionate (T4), 2% sodium butyrate (T5), and 2% sodium lactate (T6). However, Diets T 7, T8, T9, T10 and T11 were same as T 2, T3, T4, T5 and T6 except that same organic acids were supplemented at higher level i.e., @ 3% of the diet. Further, Diet T12, T13 and T14 were same as control group but supplemented with probiotic (Saccharomyces boulardii), Probiotic (Saccharomyces boulardii) + Prebiotic (MOS) and Bacitracin Methylene Disalicylate (BMD), respectively. Experiment was conducted for 6 weeks. Individual body weights of chicks and replicate-wise feed intake were recorded at weekly interval. Feed conversion ratio (FCR) was calculated as per formula. The utilization of nutrients was studied by conducting a metabolic trial at the end of the experiment, whereas to study the carcass traits, two broilers in each replicate were sacrificed on completion of experiment. Humoral immunity towards Newcastle disease was measured on day 30th and 42nd by the Haemagglutination Inhibition test. While, viable number of bacteria per gram of caecal content was determined using the Standard Plate Count media. Economics of broiler production was calculated as feed cost per kg live weight gain for total period.
In the present study, among organic acid salts (sodium acetate, calcium sorbate, calcium propionate, sodium butyrate and sodium lactate) supplemented diets, inclusion of lower levels of organic acids (2%) did not influence (P>0.05) the average total body weight and weight gain of broilers. But, increase in the level of calcium sorbate and sodium butyrate from 2 to 3% in diet of broilers increases their overall body weight as well as weight gain significantly (P<0.05). Maximum and significantly (P<0.05) higher overall body weight and weight gain was noted in broilers fed on 3% calcium sorbate. Whereas, total body weight and weight gain in broilers fed on 3% sodium acetate and calcium propionate supplemented diets were found statistically (P>0.05) similar to those fed on control diet.

Similarly, other than organic acid salts groups, experimental groups supplemented with antibiotic growth promoter (BMD) and synbiotic (Saccharomyces boulardii + MOS) showed significantly (P<0.05) higher overall body weight and weight gain.

Results on total feed intake were not significantly influenced in broilers fed on with organic acid salts, probiotic, synbiotic and antibiotic growth promoter supplemented diets, therefore, total feed intake in broilers fed different dietary treatments were found statistically (P>0.05) similar in comparison to un-supplemented diet. Results on feed conversion ratio of present study in broilers indicated that feed conversion ratio was significantly improved (P<0.05) by dietary supplementation of 3% organic acids (calcium sorbate, sodium butyrate, sodium acetate and calcium propionate) when compared with the control. Best feed efficiency (P<0.05) was noted in broilers fed on 3% calcium sorbate. Similarly, feed conversion ratio was significantly improved (P<0.05) by dietary supplementation of synbiotic and antibiotic growth promoter.

In the present study, among organic acid salts supplemented diets, digestibility of dry matter, crude protein and gross energy were not influenced at lower level (2%), but inclusion at higher level (3%) improved their digestibility. Maximum and significantly (P<0.05) higher DM, CP and GE digestibility was noted in broilers fed on 3% calcium sorbate. Experimental groups supplemented with synbiotic and antibiotic growth promoter showed better and significantly (P<0.05) higher dry matter, crude protein and gross energy digestibility.
Supplementation of organic acids (3% calcium sorbate and sodium butyrate), synbiotic and probiotic significantly (P<0.05) increased the antibody titer against NDV when compared with birds fed on none treated diets.

In the present study, among organic acid salts supplemented diets, inclusion of 2 and 3% levels of organic acids significantly (P˃0.05) lowered caecal bacterial count when compared to control. The order of bactericidal activities of different organic acids salts in used in our study were as follows from higher to lower order: calcium sorbate > sodium butyrate > calcium propionate > sodium acetate > sodium lactate. Similarly in present study antibiotic growth promoter (BMD) reduced the caecal bacterial count in broilers. However, diets supplemented with probiotic and synbiotic did not influence (P>0.05) the caecal bacterial count in broilers.

Carcass traits were not significantly influenced in broilers fed on with organic acid salts, probiotic, synbiotic and antibiotic growth promoter supplemented diets, therefore, % carcass yield (dressing weight, eviscerated weight and drawn weight) in broilers fed different dietary treatments were found statistically (P>0.05) similar in comparison to un-supplemented diet. However, no significant differences were detected on organ weights like heart, liver, gizzard, spleen and pancreas (% body weight) among treatments. Similarly, dietary treatments had no significant effect on processing losses in the present study. Thus, any of the treatments had no negative effect on carcass characteristics of broilers examined in this study.

Among organic acid salts supplemented diets, lowest feed cost per kg live weight gain for total period was observed in broilers fed on 3% calcium sorbate diet, and feed cost was higher due to supplementation of other organic acids. It might be due to better FCR and higher nutrient retention in this group. Further, different feed additives other than organic acid salts, combination of prebiotic and probiotic (synbiotic) and antibiotic growth promoter improved the economics of broilers. Under present experimental condition, synbiotic and antibiotic growth promoter appeared to be economical compared to organic acids (3% calcium sorbate) supplemented diet in terms of feed cost per kg live weight gain.
6.2 Conclusion

The results of the present experiment showed that amongst evaluated organic acid salts, 3% calcium sorbate supplementation improved overall performance, digestibility of DM, CP and GE, immune response as well as economical weight gain in broiler chickens. It is concluded, that calcium sorbate (3%) supplementation can serve as alternatives to the AGP in broiler feeds without any adverse effects on their performance.
6.3 **Suggestion for further work**

1. Studies on effect of combination of different organic acid salts on performance should be undertaken in broilers.

2. Studies on effect of different organic acid salts supplementation on the performance of egg type birds should be undertaken.
7. REFERENCES


