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Comparison of Broiler Performance and Carcass Parameters When Fed Diets Containing a Probiotic, an Organic Acid or Antibiotic Growth Promoter

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ABSTRACT

This study was conducted to compare the broiler performance and carcass measurements fed diets containing a probiotic and an organic acid with those fed a diet containing antibiotic. In a completely randomized design, 320 commercial broilers were assigned to four dietary treatments. A control negative diet was prepared based on NRC recommendations. For preparing other diets, control diet was supplemented with a probiotic, propionic acid and an antibiotic (positive control) at the levels of 0.1, 2 and 1 g kg^{-1} of diet, respectively. Metabolic body weight and feed intake were recorded on days 14, 28 and 42. At the day 43, one male chicken from each pen was randomly selected and killed for determining the carcass parameters. Metabolic weight gain just was significantly increased during the first 2 week by propionic acid. The birds fed probiotic and propionic acid, either significantly or numerically, had better feed efficiency and lower metabolic feed intake than negative control. Thigh, breast, abdominal fat and carcass yields were unaffected by probiotic and propionic acid compared to negative control birds. No significant differences were observed in viability index among experimental groups. Although there were significant differences in performance index among the negative control group and those supplemented by propionic acid and probiotic groups during the first and the second 2 week, this difference just remained significant for propionic acid during the second 2 week. In conclusion, probiotic and especially propionic acid have potential to be used as suitable alternatives to antibiotic growth promoters in starter phase of broilers nutrition.

Key words: Antibiotic, carcass parameters, performance, probiotic, propionic acid

INTRODUCTION

Antibiotic Growth Promoters (AGP_S) have been used in the poultry industry since about 50 years ago to improve poultry performance. However, the use of AGP_S in the poultry industry is completely being removed because of their potential effects on humans and the environment (Boxall *et al.*, 2003; Rooklidge, 2004). Nowadays, with the exclusion of AGP_S in different parts of the world, there is widespread concern that the removal of these feed additives will be negatively affected poultry industry. It is, therefore, of interest to look for alternatives to decrease the growth of harmful bacteria and to increase poultry performance. Probiotics and organic acids are two of several feed additives that seem to have a potential for reducing enteric diseases and for improving performance. Organic acids have been used extensively in recent years and are capable of reducing colonization of some opportunistic microorganisms, particularly *Salmonella*, in the gastrointestinal tract and in the feces by changing the bowel pH (Heres *et al.*, 2004). It is reported that organic acids can improve nutrient absorption (Boling *et al.*, 2000) by controlling intestinal microbial growth (Davidson, 2001; Chaveerach *et al.*, 2004), resulting better growth performance and feed conversion ratio.

In the other hand, probiotics are microorganisms capable of adjusting the gastrointestinal environment to the benefit of health status and of improving feed efficiency Dierck (1989). Although, the actual modes of action of probiotics in broiler chicks are not clearly understood, the recommended modes mainly includes: removal of harmful microbial such as *Salmonella* and *Campylobacter* by competitive exclusion (Jin *et al.*, 1998; Line *et al.*, 1998; Nisbet, 1998; Netherwood *et al.*, 1999; Fritts *et al.*, 2000), improving feed intake and the digestion of nutrients altering metabolism by increasing digestive enzyme activity and decreasing bacterial enzyme activity and ammonia production (Jin *et al.*, 1997) and stimulating the immune system (Gibson and Fuller, 2000; Rolfe, 2000).

Although, there is a growing number of letters investigated the effects of dietary inclusion of these feed additives on poultry diets, fewer studies compared the efficiency of probiotics and organic acids as an alternative for AGPs. Therefore, the present study was conducted to compare the broiler chicken performance and carcass measurements when fed diets containing a probiotic and an organic acid with those of broilers fed diet containing a conventional antibiotic growth promoter.

MATERIALS AND METHODS

Animals and diets: Four replicate groups, each consisting of 16 unsexed 1-d-old broiler chickens (Cobb, 500), were randomly assigned to four dietary treatment groups and reared on floor pens for 42 days. A control corn-soybean based diet (Table 1) was prepared based on National Research Council recommendations (negative control) in 1994. For preparing other treatments, the control diet was supplemented with a commercially probiotic (protexin, consisting *Lactobacillus acidophilus*, *L. bulgaricus*, *L. plantarum*, *L. rhamnosus*, *Bifidobacterium bifidum*, *Candida pintolopesii*, *Enterococcus faecium*, *Aspergillus oryzae* and *Streptococcus thermophilus* with minimum 2×10^9 CFU g^{-1} powder, obtained from Nikotech Inc., Tehran, Iran), propionic acid (Merck, Germany, obtained from Nemone Vasegh Inc., Gorgan, Iran) and flavomycin (positive control) as 0.1, 2 and 1 g kg^{-1} of diet, respectively. Propionic acid is a liquid organic acid used in poultry nutrition which has about 4.97 kcal g^{-1} and the highest gross energy among the common organic acids (Kirchgessner and Roth, 1991). No antibiotic and coccidiostat were added to water or diet during the experiment. All chicks had ad libitum access to feeds and water. The temperature of the room with continuous lighting was initially maintained at 34°C and then it was reduced by 3°C week until it reached 18°C. This temperature was maintained for the rest of the feeding period.

Experimental procedures

Metabolic Weight Gain (MWG) and Metabolic Feed Intake (MFI): MWG and MFI were recorded on the 14, 28 and 42 days of the experiment. Initial body weights were similar among the groups prior to diet allocation (average = 41 g $bird^{-1}$). Feed efficiency was calculated

Table 1: Composition of experimental (negative control) basal diet

Ingredients (kg ton^{-1})	Starter (0 to 21)	Finisher (22 to 42)
Corn	573.30	579.60
Soybean meal	369.70	335.10
Soybean oil	19.60	51.60
Dicalcium phosphate	14.10	10.90
Limestone	12.60	13.70
Salt	4.20	3.40
Premix*	5.00	5.00
DL-methionine	1.30	0.50
Vit E	0.20	0.20
Nutrient composition me (kcal kg^{-1})	29.00	31.00
Protein (%)	20.84	19.37
Ca (%)	0.90	0.95
Available P (%)	0.41	0.36
Sodium (%)	0.18	0.16
Lysine (%)	1.14	1.10
Methionine (%)	0.46	0.37
Methionine+cyctein (%)	0.82	0.73
Arginine (%)	1.37	1.27

*Premix contained 50% vitamin and 50% mineral premix that contained or exceeded levels of recommended by the National Research Council in 1994

through dividing weight gain (g) by feed intake (g). In calculation of feed conversion ratio, body weights of dead birds were also considered.

Viability and performance index: The chickens were daily inspected and the number and the body weight of dead birds were registered. Mortality rates were calculated through dividing the number of dead birds by the total number of the birds and these rates were shown as percentage. Percentage of Viability Index (VI) and Performance Index (PI) of dietary treatments were measured using the following formula:

$$VI = 100\text{-}\left(\frac{\text{Mortality in the pen}}{\text{No. of the birds in same pen}} \times 100\right)$$

$$PI = (\text{Live body weight} \times \text{Feed efficiency}) \times 100$$

Sampling procedures for carcass analysis: At the end of the experiment (43 days of age), 20 male birds (1 bird per pen with 5 pens per treatment) the nearest to the mean weight of the pen, were randomly selected, weighed and killed for determination of the carcass characteristics. Then, determination of the thigh, breast, abdominal fat and carcass yield percentage (g kg^{-1} of BW) was performed.

Statistical analysis: Statistical analysis of data was performed using Completely Randomized Design (CRD), in which the pens were signed as the experimental units. Univariate analysis of variance was performed using General Linear Model (GLM) procedures of SAS software (SAS, 2000). Differences among treatments were separated using Duncan multiple range test at 0.05 probability level.

RESULTS

The effects of using probiotic, propionic acid and flavomycin on the MWG, MFI and feed efficiency of broiler chickens are shown in Table 2. MWG was increased ($p<0.05$) by propionic acid in the first 2 week period, whereas flavomycin resulted in a significant ($p<0.05$) increase in MWG during the third 2 week period of the experiment compared to the control diet. During the second 2 week period, MWG had no significantly difference among the groups. At the first 2 week, the birds fed diets inclusion of probiotic and propionic acid had significantly lower MFI than both negative and positive control. Birds fed control diet had significantly more MFI than the propionic acid diet in the second 2 week period. During the second 2 week, flavomycin and propionic acid made a significantly lower MFI compared to those fed control diet while no significant difference was observed using a diet supplemented with probiotic. There were no significant difference among the diets for MWG and MFI in the second and third 2 week, respectively. In the first 2 week period, the birds fed any feed additives had ($p<0.05$) better average feed efficiency than control and probiotic groups. Nevertheless, FI just improved ($p<0.05$) by supplementing propionic acid and flavomycin but not by supplementing protexin, compared to the control diet, in the second 2 week period. No significant difference was found between the birds fed control diet and those fed supplemental growth promoters in the third 2 week period.

The effects of dietary treatments on the percentage of the carcass components are presented in Table 3. The thigh, breast and abdominal fat yields of birds were unaffected by inclusion of any additives while the birds fed a diet supplemented by flavomycin had higher carcass

Table 2: Mean (±SE) of control, probiotic, propionic acid and flavomycin on performance of broiler chicks

	Dietary treatment			
Item	C-	P[1]	PA[2]	C+
The first 2 week				
MWG (g)	60.82 ± 0.60^{b}	63.63 ± 3.56^{ab}	65.45 ± 1.00^{a}	64.18 ± 0.94^{ab}
MFI (g)	6.07 ± 0.11^{a}	6.06 ± 0.14^{b}	6.06 ± 0.10^{b}	6.07 ± 0.07^{a}
FE ($g\ g^{-1}$)	0.58 ± 0.01^{b}	0.65 ± 0.01^{a}	0.66 ± 0.01^{a}	0.65 ± 0.01^{a}
The second 2 week				
MWG (g)	149.31±2.08	153.85±3.46	157.94±3.35	157.65±2.46
MFI (g)	11.46 ± 0.61^{a}	11.04 ± 0.25^{ab}	9.62 ± 0.25^{c}	10.05 ± 0.15^{bc}
FE ($g\ g^{-1}$)	0.46 ± 0.02^{b}	0.48 ± 0.01^{b}	0.56 ± 0.01^{a}	0.53 ± 0.00^{a}
The third 2 week				
MWG (g)	209.24 ± 2.22^{b}	211.46 ± 0.14^{ab}	214.29 ± 4.36^{ab}	222.18 ± 3.00^{a}
MFI (g)	13.41±0.56	12.57±0.58	12.12±0.35	12.77±0.26
FE ($g\ g^{-1}$)	0.44±0.02	0.47±0.02	0.49±0.01	0.47±0.01

[a,b,c]Row means with different superscripts differ significantly at $p<0.05$. [1]Probiotic. [2]Propionic acid

Table 3: Mean (±SE) of control, probiotic, propionic acid and flavomycin on percentage of carcass components of 6-week old broiler chicks

	Dietary treatment			
Item (%)	C-	P[1]	PA[2]	C+
Tight	18.44±0.24	19.15±0.66	18.93±0.43	19.54±0.19
Breast	20.97±0.24	20.78±0.30	21.51±0.45	21.82±0.25
Abdominal fat	1.93±0.18	1.74±0.15	1.76±0.36	1.65±0.15
Carcass	60.15 ± 0.37^{b}	60.39 ± 1.24^{b}	61.64 ± 1.50^{ab}	64.08 ± 0.71^{a}

[a,b]Row means with different superscripts differ significantly at $p<0.05$. [1]Probiotic, [2]Propionic acid

yield compared to those fed by control and protexin diet ($p<0.05$). Although no significant difference was found in VI percent among the treatments, there were a significant difference ($p<0.05$) in the PI between groups fed any of the supplemental growth promoters in the first 2 week period compared to the control group. In addition, the birds fed a diet inclusion of propionic acid and flavomycin supplements had significantly better PI than control birds, in the second 2 week.

DISCUSSION

Not only must a diet provide nutrient requirements of the bird but also must regulate the body's different function (Awad *et al.*, 2006) such as regulating gastrointestinal microbiota. Probiotics and organic acids are capable of either facilitating or disturbing of the growth of intestinal harmless or harmful bacteria, respectively. Undissociated form of organic acids are capable of penetrating the membrane bacteria and of disturbing their neutral pH (Eklund, 1983). Since bacteria have to maintain an internal environment with a neutral pH, they have to frequently transport excess protons from the interior of the cell, resulting a wasting of cellular energy and finally killing the bacteria (Hinton *et al.*, 1990; Davidson, 2001). In addition, organic acids can be absorbed in the distal end of the intestinal tract and be metabolized as a substrate in the Krebs cycle (Hinton *et al.*, 1990; Hume *et al.*, 1993) for ATP production, providing an excess source of energy for growth purpose.

Reducing effects observed for performance among the birds fed diets supplemented with propionic acid and probiotic with increasing birds age, suggesting that the inclusion-timing of these additives alters their ability to have a significant effects on broiler performance. Accordantly, Higgins *et al.* (2010) observed that probiotic administration 24 h after *Salmonella enteritidis* challenge provided no protection from enteric *Salmonella* colonization, showing that the timing of the probiotic treatment is of affecting factors for reducing cecal *Salmonella* incidence. These effects may be related to the inability of young birds, especially during the first 15 days of life, for producing of suitable levels of volatile fatty acids. Anaerobic bacteria found in the intestinal microbiota of adult poultry produce volatile fatty acids as a natural mechanism of host resistance to some bacteria (Corrier *et al.*, 1990; Van der Wielen *et al.*, 2000). Therefore, because young birds do not have suitable levels of this established flora (Corrier *et al.*, 1990), inclusion of diet with organic acids and probiotic can reduce their sensitivity to pathogenic bacterial infections. In addition, organic acids can reduce bufferic capacity of diet, resulting a better protein digestion, especially in young animals having low production of stomach acid (Kirchgessner and Roth, 1982).

It is noteworthy that the birds fed propionic acid diet had, either significantly or numerically, lower metabolic feed intake than those fed control diet during the throughout the experiment. This difference may be caused either by decreasing in palatability of acidified diets because of their low tendency to absorb free H^+ ions and to have a strong taste (Cave, 1984). Consistently, Donaldson *et al.* (1994) reported decreased feed intake when 2 or 4% proprionate salts were given to newly hatched turkey poults. The birds fed any of the supplemental growth promoters had better feed efficiency during the first 2 week period and just propionic acid and flavomycin supplementations during the following 2 week period. However, none of the supplements significantly affected FE during the last period. The positive effects can be due to the higher MWG, lower feed intake and/or the improvement of conditions in the intestine that leads to improved digestion, absorption and better utilization of nutrients (Parks *et al.*, 2001; Fuller, 1999).

There are inconsistent results about the effects of feed additives on carcass composition. Although, carcass trait is influenced by both genetics and the environment at all stages

Table 4: Mean (±SE) of control, probiotic, propionic acid and flavomycin on viability index and performance index of 6 week old broiler chicks

	Dietary treatment			
Item	C-	P[1]	PA[2]	C+
The first 2 week				
[3]VI	96.15±2.58	96.25±1.53	100.00±0.00	100.00±0.00
[4]PI	14.04±0.36[b]	16.82±0.92[a]	17.46±0.54[a]	16.97±0.64[a]
The second 2 week				
VI	98.57±1.42	100.00±0.00	98.75±1.25	96.25±1.53
PI	37.16±2.34[c]	40.22±2.34[bc]	48.17±2.48[a]	45.78±0.86[ab]
The third 2 week				
VI	100.00±0.00	98.75±1.25	98.75±1.25	100.00±0.00
PI	55.34±2.90	60.43±4.00	63.80±3.82	63.96±2.26

[a,b,c]Row means with different superscripts differ significantly at $p<0.05$. [1]Probiotic, [2]Propionic acid, [3]Viability index, [4]Performance index

from pre-hatch until the end of the commercial growing period (Case *et al*., 2010), Cabel and Waldroup (1991) reported that carcass efficiency and percentage of breast meat are strongly affected by genetical factors and lightly affected by dietary subjects ones. Therefore, since in the present study, we reported the carcass parameters as a percent of MWG, the inclusion of probiotic and propionic acid had any significant difference compared to negative control diet. In the case of flavomycin, however, Visek (1978) founded the addition of some antibiotics reduces the weight and length of the intestines in poultry which has direct implications on carcass yield. No significant differences observed for inclusion of probiotic and propionic acid, for carcass parameters in our study was in agreement with result of Lesson *et al*. (2005) who founded that the inclusion of 0.2% of butyric acid compared to virginiamycin and control diets had any significant effect on carcass and breast weights of broiler chicken. Additionally, Sacakli *et al*. (2006) reported that the addition of 2.5 g organic acid had neither significant effect on carcass weight (g) and nor carcass yield (%) of quails.

The results showed that dietary growth promoters had no significant effect on the VI of broiler chicks (Table 4). No significant difference observed for VI between the birds fed control diet with those fed feed additives may be related to the environmental conditions of the experiment. In this study, well-nourished and healthy chickens were kept in a good hygienic and suitable stocking density environment resulted probably in a decreased efficacy of feed additives. We think if the chickens were challenged orally with some pathogens such as *Salmonella*, maybe viabilities were far from those achieved in this study. Similar effects were found with broiler chicks were fed diets supplemented with probiotics (Karaoglu and Durdag, 2005; Aftahi *et al*., 2006). In the case of PI, all the chicks but not protexin at the second 2 week, fed with growth promoters had better PI during the two first 2 week period than the chicks of control group, due to their better feed efficiency and MWG. In accordance with this result, other researchers observed that inclusion of yoghurt and probiotic (Aftahi *et al*., 2006) and different levels of lactic and citric acids (Abdel-Fattah *et al*., 2008) as feed additives improved the PI of broiler chicks.

In conclusion, some results of this study demonstrated that probiotic and especially propionic acid have potential to be used as suitable alternative to AGP_S in terms of some performances criteria, especially in starter phase of broilers nutrition. However, further studies are necessary to amplify the results of this experiment and to determine whether these results are likely to be applicable for other rearing conditions.

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