www.roavs.com ISSN: 2223-0343 (ONLINE)
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Effect of different levels of synbiotics on carcass characteristics of broiler

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Abstract

Two hundred broiler chickens (Ross 308) were randomly subjected to five treatments. Treatments included a control without any treatment. The other treatments included recommended level (0.1% in starter, 0.05% in grower, and 0.025% in finisher) of synbiotics, Biomin IMBO (Biomin Co, Austria), 25% reduced level than recommended level, 25 and 50% higher level than recommended level. The synbiotics IMBO Biomin contains probiotics bacteria *Enterococcus faecium* and prebiotic fructo-oligosacherides. During the experiment, food and water were available *ad libitum* to the chickens for 42 days. In the current study, the lung percentage was significantly high in 50 percent higher level of synbiotics in broiler chickens. Brain percentage was significantly low in company recommended level and 25 percent increase in recommended level. Rachis weight was significantly high in recommended level of the company or 25 percent higher than this amount. The results indicated that the current levels of this product had no effect on the carcass quality of the broiler chickens.

Keywords: Broiler; carcass; synbiotics

To cite this article: Aziz Mousavi, SMA, AR Seidavi, M Dadashbeiki, 2012. Effect of different levels of synbiotics on carcass characteristics of broiler. Res. Opin. Anim. Vet. Sci., 2012, 2(3), 161-165.

Introduction

Probiotics are live microorganisms which are considered as alternative to antibiotics. These compounds can improve performance and health status of bird through the mechanism of competitive exclusion and balance of gut microbial population (Stavric and Kornegy, 1995; Fuller, 1998). Prebiotics are nutrients that are indigestible in the gut or less to digest and their useful impact in human health is through increased growth or activity of a limited number of probiotics bacteria in the colon. Lactose, galacto oligosaccharides, fructo-oligosaccharides, and its hydrolyzed metabolites, malto-oligosaccharides are among the prebiotics most commonly used in human nutrition. The end products of carbohydrates metabolism are short chain fatty acids (such as acetate, butyrate and propionate) which are used as energy source for host organisms. Synbiotics is a combination of beneficial species of probiotics and prebiotics, the concomitant use of these compounds is useful for synergistic effect. In fact, the main reason to use a synbiotics is that probiotics without prebiotics may not survive in the environment; because prebiotics are a food source of probiotics (Batavani, 2010). Hosseyni Abrishami et al. (2010) reported that prebiotics (Fermecto) and probiotics (cultured intestinal contents) increased the number of Lactobacillus and increase aerobic bacteria in broilers at the age of forty-two days in the digestive system.

The aim of this research was to study synbiotics (Biomin IMBO) effect on carcass characteristics in broiler chickens.

Materials and Methods

This study was designed to examine the effectiveness of symbiotic (Biomin IMBO) on carcass characteristics of broilers in the Poultry House of Faculty of Agriculture, Islamic Azad University, Rasht Branch, Rasht, Iran. The synbiotics IMBO Biomin contains probiotics bacteria *Enterococcus faecium* and prebiotic fructo-oligosacherides. A total of 200 one-day

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broilers (Ross 308) were divided into five treatments (ten replicates) in a randomized design. The composition of synbiotics treatment is given in Table 1. Throughout the experiment, the birds had free access to the clean drinking water.

Table 1: Biomin synbiotics[1] amounts in studied diets (%)

	Starter	Grower	Finisher
Control Group	0	0	0
Recommended by company	0.1	0.05	0.025
25% decrease in recommended level of company	0.075	0.0375	0.01875
25% increase in recommended level of company	0.125	0.0625	0.03125
50% increase in recommended level of company	0.15	0.075	0.0375

[1] Manufactured by Biomin Co, Austria

Experimental diets for the three periods (Starter, Grower and Finisher) were prepared according to the recommendation given in the guide of Ross broilers 308. Starter, grower and finisher period were two weeks, three weeks and one week, respectively. Composition of the experiment diets and their chemical analysis in the starter, grower and finisher period are in Tables 2 and 3 respectively.

Table 2: Composition of basal diets

Ingredient	Starter	Grower	Finisher
Corn (%)	46.09	50.91	48.88
Soybean meal (%)	40.00	35.00	39.97
Fish meal (%)	3.00	3.00	-
Meat meal (%)	3.00	3.00	-
Oil (%)	4.56	5.45	7.38
DL-Methionine (%)	0.29	0.23	0.17
L-Lysine (%)	0.04	-	-
L-Threonine (%)	0.03	-	-
Ca22%,P18% (%)	0.99	0.75	1.64
CaCO3 (%)	0.98	0.76	1.00
K-Bicarbonate (%)	0.05	0.03	-
NaCl (%)	0.37	0.37	0.45
Vitamin and Mineral Mixture[1] (%)	0.60	0.50	0.50
Total (%)	100	100	100

[1] Vitamin A: 5000 IU/gr; Vitamin D3: 500 IU/gr; Vitamin E: 3 mg/gr; Vitamin K3: 1.5 mg/gr; Vitamin B2: 1 mg/gr; Calcium Pantothenate: 4 mg/gr; Niacin: 15 mg/gr; Vitamin B6: 13 mg/gr; Cu: 3 mg/gr; Zn: 15 mg/gr; Mn: 20 mg/gr; Fe: 10 mg/gr; K: 0.3 mg/gr

On the final day (42 days), three birds were slaughtered and the different parts of the carcasses were removed and compared with each other. Weight of each of these organs was measured by digital scale with a precision of 1 g. Also, different parts of the intestine were measured by digital caliper and centimeter.

Table 3: Chemical analysis of basal diet

Ingredient	Starter	Grower	Finisher
Energy (kcal/kg)	3025	3150	3200
Protein (%)	24.9	23	22
Lysine (%)	1.41	1.26	1.22
Methionine (%)	0.67	0.59	0.50
Met+Cys (%)	1.05	0.94	0.85
Threonine (%)	1.98	0.87	0.85
Tryptophan (%)	0.30	0.27	0.28
Arginine (%)	1.68	1.54	1.51
Iso-Leucine (%)	1.04	0.95	0.94
Valine (%)	1.60	1.07	1.03
Leucine (%)	1.99	1.87	1.82
Calcium (%)	1.05	0.90	0.85
Available Phosphorus (%)	0.50	0.45	0.42
Sodium (%)	0.23	0.23	0.20
Potassium (%)	1.00	0.90	0.93
Chloride (%)	0.30	0.30	0.30
DCAB (mEq/Kg)	272.12	244.55	242.77
Choline (g/Kg)	1.48	1.37	1.37
Linoleic Acid (%)	1.21	1.27	1.24
Crude Fiber (%)	3.78	3.52	3.73
Ether Extract (%)	6.84	7.87	9.22

Statistical analysis

This experiment was conducted in a randomized complete block design. Data were statistically analyzed with SPSS statistical software and averages were compared by Turkey test.

Results

In the current study, the lung percentage was significantly high in 50 percent higher level of synbiotics in broiler chickens. Brain percentage was significantly low in company recommended level and 25 percent increase in recommended level. Rachis weight was significantly high in recommended level of the company or 25 percent higher than this amount.

Discussion

In this study, various parameters of carcass characteristics were studied. Results showed that the addition of synbiotics had a significant impact on lung and brain percentage and rachis. Mahajan et al. (2000) reported significant increase in fresh carcass weight fed with probiotics (saccharomyces + lactobacilus). Karimzade and Mohammadzade (2010) investigated the effect of probiotics supplements, organic acids and antibiotic in broiler and found that liver weight and abdominal fat weight were not significantly different.

Mohammad Jafare et al. (2010) reported that 0.2 percent of probiotics had no significant impact on the live weight, abdominal fat weight and mortality percentage, the percentage of the thigh, abdominal fat, heart weight, heart percentage, relative weight of bursa fabricius and bursa fabricius relative percentage had not

Table 4: Mean ±SEM of carcass characteristics in control and treated groups

Treatments	Live weight (gm)	Without feather carcass weight (gm)	Full carcass weight (gm)	Empty carcass weight (gm)	Empty carcass percentage	Head weight (gm)	Head percentage	Breast meat weight (gm)	Breast meat percentage
Control	2333.75 ±119.08[a]	1961.25 ±100.01[a]	1895.90 ±94.51[a]	1347.5 ±69.33[a]	68.72 ±0.67[a]	49.87 ±3.45[a]	2.54 ±0.16[a]	490.25 ±38.41[a]	24.95 ±0.81[a]
Recommended level of company	2178.75 ±100.51[a]	1795 ±81.47[a]	1740.58 ±78.78[a]	1237.5 ±64.21[a]	68.89 ±0.63[a]	51.28 ±3.83[a]	2.58 ±0.21[a]	440.75 ±30.55[a]	24.50 ±0.69[a]
25% decrease in recommended level of company	2511.25 ±140.54[a]	2055 ±114.18[a]	1984.96 ±107.17[a]	1403.75 ±70.22[a]	68.37 ±0.29[a]	53.12 ±1.41[a]	2.60 ±0.22[a]	540.00 ±48.58[a]	26.14 ±0.71[a]
25% increase in recommended level of company	2565 ±11.90[a]	2092.50 ±7.50[a]	2034.84 ±26.76[a]	1455 ±48.73[a]	69.52 ±1.33[a]	55.83 ±3.57[a]	2.67 ±0.29[a]	566.00 ±64.13[a]	27.03 ±1.39[a]
50% increase in recommended level of company	2540 ±82.56[a]	2108.75 ±69.86[a]	2039.57 ±67.48[a]	1451.25 ±63.49[a]	68.75 ±0.58[a]	56.21 ±2.62[a]	2.67 ±0.17[a]	594.75 ±28.42[a]	28.18 ±0.39[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

Table 5: Mean ±SEM of carcass characteristics in control and treated groups

Treatments	Wings weight (gm)	Wings percentage	Femur meat weight (gm)	Femur meat percentage	Abdominal fat weight (gm)	Abdominal fat percentage	Pancreas weight (gm)	Pancreas percentage	Full gizzard weight (gm)	Full gizzard percentage
Control	129.07 ±7.44[a]	6.59 ±0.33[a]	456.75 ±30.01[a]	23.30 ±0.78[a]	36.36 ±4.34[a]	1.85 ±0.40[a]	6.67 ±0.90[a]	0.34 ±0.16[a]	54.37 ±5.70[a]	2.76 ±0.34[a]
Recommended level of company	113.00 ±3.73[a]	6.32 ±0.29[a]	457.25 ±16.48[a]	25.51 ±0.21[a]	51.34 ±4.44[a]	2.88 ±0.51[a]	6.56 ±0.42[a]	0.37 ±0.08[a]	50.56 ±3.96[a]	2.81 ±0.30[a]
25% decrease in recommended level of company	129.64 ±7.76[a]	6.30 ±0.06[a]	488.00 ±26.87[a]	23.82 ±0.76[a]	41.52 ±4.31[a]	2.05 ±0.53[a]	6.98 ±0.46[a]	0.34 ±0.02[a]	57.11 ±1.71[a]	2.80 ±0.28[a]
25% increase in recommended level of company	131.00 ±5.87[a]	6.26 ±0.33[a]	538.00 ±11.07[a]	25.71 ±0.33[a]	54.53 ±9.24[a]	2.61 ±0.87[a]	7.26 ±1.01[a]	0.35 ±0.24[a]	56.91 ±3.76[a]	2.72 ±0.33[a]
50% increase in recommended level of company	125.75 ±4.69[a]	5.97 ±0.25[a]	532.00 ±22.55[a]	25.21 ±0.27[a]	44.10 ±7.15[a]	2.08 ±0.64[a]	6.93 ±0.60[a]	0.33 ±0.09[a]	64.87 ±5.22[a]	3.10 ±0.52[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

Table 6: Mean ± SEM of carcass characteristics of control and treated groups

Treatments	Lung weight (gm)	Lung percentage	Heart weight (gm)	Heart percentage	Liver weight (gm)	Liver percentage	Kidney weight (gm)	Kidney percentage	Spleen weight (gm)	Spleen percentage
Control	16.05 ±0.90[a]	0.81 ±0.01[a]	18.32 ±1.91[a]	0.93 ±0.16[a]	61.02 ±3.09[a]	3.11 ±0.12[a]	18.33 ±1.66[a]	0.93 ±0.18[a]	2.49 ±0.26[a]	0.127 ±0.096[a]
Recommended level of company	12.90 ±0.49[a]	0.72 ±0.02[b]	15.18 ±1.10[a]	0.85 ±0.18[a]	50.19 ±2.30[a]	2.80 ±0.12[a]	14.20 ±1.67[a]	0.79 ±0.24[a]	2.25 ±0.16[a]	0.125 ±0.066[a]
25% decrease in recommended level of company	16.25 ±1.05[a]	0.79 ±0.09[a]	18.48 ±0.93[a]	0.90 ±0.12[a]	61.52 ±3.44[a]	3.00 ±0.15[a]	18.60 ±1.82[a]	0.92 ±0.17[a]	2.47 ±0.12[a]	0.121 ±0.054[a]
25% increase in recommended level of company	12.98 ±1.01[a]	0.60 ±0.04[b]	16.46 ±1.51[a]	0.77 ±0.15[a]	57.91 ±2.35[a]	2.74 ±0.07[a]	15.97 ±1.86[a]	0.75 ±0.25[a]	2.46 ±0.11[a]	0.117 ±0.059[a]
50% increase in recommended level of company	13.64 ±0.31[a]	0.65 ±0.02[b]	16.13 ±0.80[a]	0.77 ±0.12[a]	57.33 ±3.94[a]	2.74 ±0.34[a]	18.90 ±1.44[a]	0.90 ±0.22[a]	2.84 ±0.32[a]	0.136 ±0.150[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

Table 7: Mean ± SEM of carcass characteristics of control and treated groups

Treatments	Thymus weight (gm)	Thymus percentage	Bursa fabricius weight (gm)	Bursa fabricius percentage	Brain weight (gm)	Brain percentage	Testicles weight (gm)	Testicles percentage	Duodenum weight (gm)	Duodenum percentage
Control	5.72 ±1.23[a]	0.26 ±0.40[a]	2.62 ±0.71[a]	0.15 ±0.25[a]	2.62 ±0.12[a]	0.27 ±0.07[a]	0.45 ±0.08[a]	0.048 ±0.32[a]	25.67 ±2.56[a]	0.99 ±1.46[a]
Recommended level of company	4.99 ±0.84[a]	0.27 ±0.19[a]	2.10 ±0.15[a]	0.12 ±0.05[a]	2.88 ±0.07[a]	0.15 ±0.5[b]	0.58 ±0.07[a]	0.032 ±0.05[a]	21.03 ±1.91[a]	1.18 ±0.36[a]
25% decrease in recommended level of company	7.95 ±0.98[a]	0.39 ±0.26[a]	3.27 ±0.19[a]	0.16 ±0.11[a]	2.83 ±0.03[a]	0.13 ±0.01[b]	0.57 ±0.10[a]	0.027 ±0.07[a]	22.26 ±1.03[a]	1.10 ±0.28[a]
25% increase in recommended level of company	6.59 ±2.00[a]	0.33 ±0.50[a]	2.99 ±0.25[a]	0.14 ±0.09[a]	2.95 ±0.08[a]	0.14 ±0.6[b]	0.69 ±0.12[a]	0.033 ±0.08[a]	25.44 ±2.39[a]	1.22 ±0.31[a]
50% increase in recommended level of company	6.99 ±1.86[a]	0.31 ±0.49[a]	3.66 ±0.39[a]	0.17 ±0.16[a]	2.86 ±0.05[a]	0.13 ±0.04[b]	0.52 ±0.03[a]	0.025 ±0.04[a]	23.36 ±4.17[a]	1.10 ±0.56[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

Table 8: Mean ± SEM of carcass characteristics of control and treated groups

Treatments	Ileum weight (gm)	Ileum percentage	Jejunum weight (gm)	Jejunum percentage	Ceca weight (gm)	Ceca percentage	Rachis weight (gm)	Rachis percentage	Proventriculus weight (gm)	Proventriculus percentage
Control	15.52 ±2.33[a]	0.90 ±0.42[a]	122.69 ±11.51[a]	5.19 ±2.50[a]	14.31 ±2.12[a]	1.79 ±2.07[a]	11.27 ±1.22[b]	1.41 ±0.63[a]	11.10 ±0.60[a]	0.78 ±0.60[a]
Recommended level of company	13.52 ±2.02[a]	0.74 ±0.26[a]	109.29 ±5.17[a]	6.09 ±0.21[a]	11.18 ±0.94[a]	0.62 ±0.19[a]	36.60 ±1.42[ab]	2.03 ±0.13[a]	11.45 ±0.43[a]	0.64 ±0.16[a]
25% decrease in recommended level of company	13.83 ±2.60[a]	0.66 ±0.36[a]	125.63 ±10.22[a]	6.11 ±0.42[a]	14.93 ±2.78[a]	0.71 ±0.38[a]	41.00 ±2.67[a]	1.95 ±0.26[a]	12.42 ±1.01[a]	0.61 ±0.17[a]
25% increase in recommended level of company	11.18 ±2.14[a]	0.53 ±0.44[a]	127.06 ±8.92[a]	6.08 ±0.53[a]	18.44 ±0.15[a]	0.88 ±0.032[a]	36.04 ±3.04[ab]	1.72 ±0.31[a]	11.97 ±0.88[a]	0.57 ±0.17[a]
50% increase in recommended level of company	14.37 ±0.44[a]	0.68 ±0.12[a]	121.10 ±12.46[a]	5.71 ±0.55[a]	16.65 ±1.17[a]	0.80 ±0.26[a]	34.75 ±1.14[ab]	1.67 ±0.17[a]	11.75 ±1.10[a]	0.56 ±2.06[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

Table 9: Mean ± SEM of carcass characteristics of control and treated groups

Treatments	Neck weight (gm)	Neck percentage	Duodenum length (cm)	Duodenum width (mm	Duodenum diameter (mm)	Ileum length (cm)	Ileum width (mm)	Ileum diameter (mm)	Jejunum length (cm)	Jejunum width (mm)	Jejunum diameter (mm)
Control	53.55 ±6.12[a]	2.26 ±1.41[a]	37.62 ±1.86[a]	9.26 ±0.76[a]	0.44 ±1.67[a]	22.52 ±1.46[a]	8.53 ±1.08[a]	0.44 ±0.799[a]	144.00 ±2.71[a]	11.86 ±0.76[a]	0.50 ±1.15[a]
Recommended level of company	25.50 ±3.93[a]	2.93 ±0.29[a]	32.07 ±6.68[a]	8.81 ±0.74[a]	0.32 ±0.56[a]	22.12 ±1.39[a]	9.73 ±0.50[a]	0.37 ±0.493[a]	142.50 ±8.11[a]	11.03 ±0.98[a]	0.26 ±0.26[a]
25% decrease in recommended level of company	57.65 ±3.30[a]	2.82 ±0.34[a]	40.50 ±0.54[a]	9.71 ±0.17[a]	0.40 ±0.42[a]	26.00 ±4.70[a]	9.31 ±0.46[a]	0.30 ±1.188[a]	149.87 ±5.19[a]	11.06 ±0.24[a]	0.34 ±1.63[a]
25% increase in recommended level of company	61.33 ±2.41[a]	2.89 ±0.28[a]	42.45 ±1.07[a]	9.54 ±0.38[a]	0.57 ±0.39[a]	22.27 ±3.29[a]	7.81 ±0.61[a]	0.26 ±1.552[a]	155.50 ±1.55[a]	9.87 ±0.77[a]	0.47 ±0.73[a]
50% increase in recommended level of company	60.37 ±3.99[a]	2.91 ±0.10[a]	41.25 ±4.36[a]	9.20 ±0.23[a]	0.30 ±1.22[a]	20.82 ±2.88[a]	9.09 ±0.36[a]	0.31 ±0.425[a]	151.25 ±3.49[a]	11.40 ±1.14[a]	0.43 ±0.29[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

Table 10: Mean ± SEM of carcass characteristics of control and treated groups

Treatments	Left cecum length (cm)	Left cecum width (mm)	Left cecum diameter (mm)	colon Wight (gm)	colon length (cm)	colon width (mm)	colon diameter (mm)
Control	20.87 ±1.14[a]	9.83 ±1.84[a]	0.46 ±1.85[a]	5.46 ±0.73[a]	11.62 ±1.31[a]	9.55 ±1.38[a]	0.39 ±0.43[a]
Recommended level of company	19.87 ±0.72[a]	9.93 ±0.95[a]	0.60 ±0.61[a]	5.16 ±0.80[a]	10.87 ±0.85[a]	9.47 ±0.74[a]	0.44 ±0.37[a]
25% decrease in recommended level of company	22.15 ±0.82[a]	10.53 ±1.51[a]	0.42 ±1.50[a]	5.58 ±1.23[a]	11.25 ±1.56[a]	9.29 ±1.26[a]	0.41 ±1.52[a]
25% increase in recommended level of company	23.25 ±0.32[a]	11.02 ±0.69[a]	0.40 ±0.21[a]	4.33 ±0.95[a]	11.42 ±1.94[a]	7.87 ±0.54[a]	0.46 ±1.55[a]
50% increase in recommended level of company	21.87 ±0.90[a]	14.39 ±0.48[a]	0.60 ±0.59[a]	5.17 ±0.81[a]	10.20 ±0.82[a]	10.47 ±1.87[a]	0.36 ±1.73[a]

Means in each column followed by the same letters are not significantly different (P<0.05)

significant impact (P>0.05). Awad et al. (2009) investigated the intestinal structure and function of broiler chickens fed with a synbiotics containing *Enterococcus faecium* and oligosaccharide. Results indicate significant improvement in the structure and function of the chicken intestine. Except few parameters, this synbiotics product had no significant effect on carcass characteristics.

Acknowledgments

This manuscript is a part of MSc. thesis of Seyed Mohammad Ali Aziz Mousavi, Rasht Branch, Islamic Azad University, Rasht, Iran. We are grateful to the Rasht Branch, Islamic Azad University, Rasht, Iran for support.

References

Awad, W.A., Ghareeb, K., Abdel-Raheem, S. and Böhm, J. 2009. Effects of dietary inclusion of probiotics and synbioticson on growth performance, organ weights, and intestinal histomorphology of broiler chickens. *Poultry Science*, 88:49-56.

Batavani, A. 2010. The composition of probiotics and prebiotics of Immune system stimulants- Publisher of research group of Itook Farda.

Fuller, R. 1998. Probiotics for animals. Horizon Scientific Press. Wymondham.

Hosseyni Abrishami, M., Khahsare Zareha, V., Kermanshahi, H. and Pilevar, M. 2010. Study of Different Levels prebiotics (Fermacto) and probiotics (cecal cultured) Effects on Growth Performance, Microbial Population of Digestive System in Broiler .Proceeding of the 4th Congress on Animal Science, College of Agriculture and Natural Resources, Tehran University, Iran, Karaj.

Karimzade, S. and Mohammadzade, H. 2010. Effect of probiotics, organic Acid and antibiotic supplementation on broiler performance and carcass yield**.** Proceeding of the 4th Congress on Animal Science, College of Agriculture and Natural Resources, Tehran University, Iran, Karaj.

Mahajan, P., Sahoo, J. and Panda, P.C. 2000. Effect of probiotics (Lacto-Sacc) feeding, packaging methods and season on the microbial and organoleptic qualities of chicken meat balls during refrigerated storage. *Journal of Food Science Technology of Mysore*, 37: 67-71.

Mohamad Jafare, A., Karimzadeh, S. and Mohamadzadeh, H. 2010. Determination of the effect of probiotics supplementation on growth performance, carcass Characteristics, blood factors and mortality percent of broiler Chicks. Proceeding of the 4th Congress on Animal Science, College of Agriculture and Natural Resources, Tehran University, Iran, Karaj.

Stavric, S. and Kornegy, E.T. 1995. Microbial probiotics for pigs and poultry. In: (Eds.), Thomas Haker Pub. Brelin, Germany. Wallace, J. and Chesson, A. *Biotechnology in Animal Feed and Animal Feeding*.