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Effects of dietary supplementations of prebiotics, probiotics, synbiotics and acidifiers on growth performance and organs weights of broiler chicken

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ABSTRACT

This experimental trial was conducted to investigate the effects of dietary supplementations of prebiotic, probiotic, synbiotic and acidifier on broiler performance and organ's weights of broiler chickens. One hundred and sixty 1-d-old Ross 308 broiler chickens were randomly assigned to one of five dietary treatments for six week. The dietary treatments were 1- Control, 2- Basal diets supplemented with prebiotic (1kg of ActiveMOS/ton) 3- Basal diets supplemented with probiotic (150/100/50gr of Protexin/ton of the starter, grower and final diets respectively) 4- Basal diets supplemented with synbiotic (1kg of Amax4x/ton) 5- Basal diets supplemented with acidifier (2 liter Globacid/ton). The highest body weight observed in synbiotic group, which was significantly (P<0.05) higher than control group. Prebiotic and acidifier groups showed similar body weight as synbiotic group (P>0.05) but higher than control group (P<0.05). The body weight of broilers in probiotic group was similar to control, prebiotic and acidifier groups (P>0.05). Daily weight gain were significantly (P<0.05) increased in experimental groups compare the control group. Total feed intake did not show any significant (P>0.05) difference between experimental groups. Feed conversion ratio decreased significantly (P<0.05) in synbiotic and acidifier groups compare the control group. However, there were no significant (P>0.05) differences in feed conversion ratio of broiler chickens in prebiotic and probiotic groups compared with control group. The weight of proventriculus, Gizzard, liver, and Bursa did not differ (P>0.05) between groups. Additionally, the weight of Spleen increased significantly (P<0.05) in probiotic group compared with control group.

Keywords: feed additives, growth performance, internal organs, Broiler

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INTRODUCTION

In the modern intensive poultry production, newly hatched chicks have little chance of contact with their mothers and consequently normal microflora is slow in colonizing the intestine [1]. So Antibiotics were used worldwide in poultry industry in the past 60 years for preventing diseases and improvement of growth performance. But continuous and misuses of antibiotics in livestock production and specially poultry industry resulted many concerns about development of drug-resistant bacteria [2], drug residues in the body of the birds [3], and imbalance of normal microflora [4]. Therefore, importance of using alternative growth promoters such as prebiotic, probiotic, synbiotic and acidifier is evident.

A prebiotic was defined as nondigestible food ingredients that beneficially affect the host, selectively stimulating the growth or activity, or both, of one or a limited number of bacteria in the colon [5]. Some studies demonstrated the beneficial effects of prebiotics on improvement of growth performance [6-7-8]. Probiotics are "live microorganisms which, when administered in adequate amount, confer a health benefit on the host" [9]. Several studies reported that probiotics have beneficial effects on growth performance [10-11-12-13-14-15-16-17-18]. The combination of a pre- and probiotic in 1 product has been shown to confer benefits beyond those of either on its own [19]. A way of potentiating the efficacy of probiotic preparations may be the combination of both probiotics and prebiotics as synbiotics, which may be defined as a mixture of probiotics and prebiotics that beneficially affects the host by improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract [16]. The acidifiers can modify the PH of both the feed and the animal`s digestive tract and can disrupt the normal cell function and protein synthesis of various gut microorganisms [21]. In addition, it has been suggested that lowering the pH by organic acids improves nutrient absorption [20]. Several studies support the statement that dietary inclusions of acidifiers have improved growth performance in broiler chickens [22-23-24-25-26-27].

The objective of the current study was to compare the effects of prebiotics, probiotics, synbiotics and acidifiers as dietary supplementations on the growth performance and weight of internal organs in the broiler chickens.

MATERIALS AND METHODS

Birds, diet and experimental design

One hundred and sixty 1-day-old Ross 308 broilers (mixed sex) were used in this study. The chickens were randomly divided into a control group and 4 experimental groups. There were 8 chickens in each replicate and 4 replicates per treatment group (32 birds/group). The birds were housed in separate floor pens (1.2 × 0.9) with a wood shaving floor and had free access to feed and water. During the 42 days of experimental period, environmental factors (lightning, temperature, humidity, ventilation) maintain on optimal levels recommended for Ross 308 broiler chickens. A corn-soybean meal-based diet was formulated for chickens.

Experimental treatments were: 1- Control group: basal diet 2- Prebiotic group: basal diets supplemented with prebiotic (Active MOS, Tabriz, Iran) 1 kg/ton 3- probiotic group: basal diets supplemented with probiotic (Protexin. Tabriz, Iran) 150gr/ton of the starter diets, 100gr/ton of the grower diets and 50gr/ton of the final diets 4- Synbiotic group: basal diets supplemented with synbiotic (Amax4x, USA) 1 kg/ton 5- Acidifier group: basal diets supplemented with acidifier (Globacid DW) 2 liter/ton.

Performance parameters and measurements

All birds were weighed individually at the end of each week of experimental period (6 weeks). The weight of first day (after arriving to the experimental farm) and 42 days of age was known respectively as initial and final weight. Feed conservation ratio and daily weight gain was calculated for the starter, grower and finisher phase of the experiment. At the end of experiment, 8 birds per treatment (2 birds/replicate) were randomly selected and euthanized by cervical dislocation. After opening abdominal cavity, proventriculus, gizzard, liver, spleen and bursa of fabricius were weighed individually and recorded.

Statistical Analysis

Statistical analyses were conducted with the Statistical Package for Social Science (SPSS for Windows Version 15; SPSS GmbH, Munich, Germany) to determine if variables differed between groups. Results are expressed as means ± SEM. The body weight, daily weight gain, feed intake, feed conversion ratio and organ weights were compared between groups by 1-way ANOVA and subsequent Duncan's multiple range test. Probability values of less than 0.05 ($P<0.05$) were considered significant.

RESULTS AND DISCUSSION

The effects of dietary supplementations of prebiotic, probiotic, synbiotic and acidifier on growth performance parameters are summarized in Table 1. There was no significant ($P>0.05$) difference in body weight of broilers between experimental groups on day 14. The body weight of broilers supplemented with synbiotic was significantly ($P<0.05$) higher than broilers in control group on day 28. At the end of the experiment (day 42), broilers supplemented with prebiotic, synbiotic and acidifier had higher body weight in compare of control group ($P<0.05$). However, the difference in body weight of broilers between probiotic and control groups was not significant ($P>0.05$). These results are in agreement with earlier studies [16, 25, 26, 27, 28, 29, 30]. Zakeri and Kashefi (2011) found that dietary inclusion of mannanoligosaccharide (MOS) increased body weight of broilers in compare of control group. Ortiz et al. (2009) observed no effect of dietary inclusion of inulin as a prebiotic on body weight in broiler chickens, whereas EL-Banna et al. (2010) found that dietary inclusion of two different prebiotics increased

body weight significantly at the end of the experiment. It has been reported that dietary inclusion of synbiotic had a beneficial effect on body weight of broilers [16, 28, 29]. Chowdhury et al. (2009) found that citric acid supplementation as an acidifier caused a significant increase on body weight in broiler chickens, whereas Bonos et al. (2012) observed no effect on body weight of Japanese quail by addition of acidifiers to diets. Abdel-Fattah et al. (2008) found that the addition of dietary citric acid, acetic acid, or lactic acid improved body weight of broiler chickens compared with control group. Similar results were found by other researchers [25, 26]. Awad et al. (2009) reported that addition of probiotic to broilers diet did not show any significant effect on body weight compared with control group. In contrast, Mountzouris et al (2010) observed that diets containing 10^8 cfu probiotic/kg increased body weight of broilers significantly in compare of control group. In agreement with our findings, it's reported that dietary supplementation of probiotic did not affect body weight of broilers [28, 34, 35].

Between days 1-14, there was no significant ($P>0.05$) difference in daily weight gain of broilers between experimental groups. Daily weight gain of broilers on days 15-28, increased significantly ($P<0.05$) in experimental groups compare the control group. Also, between days 29-42, daily weight gain of broilers in experimental groups was significantly ($P<0.05$) higher than control group. During the whole period of experiment, daily weight gain of broilers in prebiotic, synbiotic and acidifier groups were significantly ($P<0.05$) higher than control group. However, there was no significant difference ($P>0.05$) between probiotic and control groups. Jung et al (2008) found that addition of galacto-oligosaccharides (GOS) and Bifidobacterium lactis had no significant effect on weight gain of broiler chickens. Awad et al. (2009) found that dietary inclusion of synbiotic increased daily weight gain of broilers significantly whereas; addition of probiotic had no significant effect. Similar findings were reported by other researchers [28, 29]. Chowdhury et al. (2009) reported that addition of citric acid to broilers diet increased weight gain significantly compare to the control group.

Feed intake of broilers did not differ significantly ($P>0.05$) between experimental groups on days 1-14. Between days 15-28, feed intake of broilers in prebiotic, probiotic and synbiotic groups was significantly ($P<0.05$) higher than control group. On days 29-42, feed intake increased significantly in prebiotic group compare the probiotic and synbiotic groups. During the entire period of experiment, there was not any significant ($P>0.05$) difference between groups. Salianeh et al. (2011) reported that dietary inclusion of prebiotic significantly decreased feed intake in broiler chickens compared with control group, whereas, addition of probiotic did not have the same effect as prebiotic. Samli et al (2007) found that feed intake of broilers did not differ significantly by dietary inclusion of probiotics. Similar results were found by Jung et al. (2008) who found that addition of prebiotic and probiotic did not have any significant effect on feed intake of broiler chickens. Nezhad et al. (2007) found that the addition of citric acid did not affect feed intake in broilers supplemented with citric acid and similar results were found by Chowdhury et al. (2009). However, this observation was not found by the findings of Moghadam et al. (2006), who reported that the effects of citric acid on feed intake of broilers were significant.

Feed conversion ratio (FCR) did not differ significantly ($P>0.05$) between groups on days 1-14. Between days 15-28, there was a significant ($P<0.05$) decrease in feed conversion ratio of broiler chickens in synbiotic and acidifier groups n compared with the control group. Between days 29-42, feed conversion ratio in Synbiotic and Acidifier groups were significantly ($P<0.05$) lower than control group. At the whole experimental period, feed conversion ratio in Synbiotic and Acidifier groups were significantly ($P<0.05$) lower than control group However, there was no significant differences in prebiotic and probiotic groups compared with each other, comparing the control group and also compared to synbiotic and acidifier groups ($P>0.05$). In agreement with our findings, Jung et al. (2008) reported that dietary inclusion of prebiotic and probiotic had no significant effect on feed conversion ratio in broiler chickens and similar results were found by Ortiz et al. (2009). Salianeh et al. (2011) observed that addition of prebiotic decreased feed conversion ration significantly, however, probiotic supplementation did not affect feed conversion ratio in broiler chickens. In contrast, Talebi et al. (2008) reported that addition of probiotic to broiler chicken diets decreased feed conversion ratio significantly. It has been reported that addition of synbiotic to broilers diet significantly decrease feed conversion ratio in broiler chickens [29]. Awad et al. (2009) reported that dietary supplementation of synbiotic significantly decreased feed conversion ratio, while addition of probiotic had no significant effect. In agreement with our studies, Chowdhury et al. (2009) found that dietary inclusion of citric acid significantly decreased feed conversion ratio in broiler chickens compared with control group. Similar results were found by other researchers [22, 23, 27].

Table 1: Growth performance of broilers[1]

	Dietary treatment					
	Control	Prebiotic	Probiotic	Synbiotic	Acidifier	P Value
Body weight						
d 1 (g)	42.70 ± 1.58	43.10 ± 1.20	42.45 ± 1.34	41.95 ± 1.59	42.90 ± 1.27	0.981
d 14 (g)	324.07 ± 7.56	324.56 ± 8.24	323.3 ± 7.19	328.77 ± 7.69	330.51 ± 7.75	0.949
d 28 (g)	1004.92^{a} ± 16.01	1041.91^{ab} ± 14.85	1029.73^{ab} ± 15.63	1059.04^{b} ± 14.58	1051.35^{ab} ± 15.81	0.163
d 42 (g)	2011.26^{a} ± 21.19	2097.91^{bc} ± 23.32	2075.57^{ab} ± 23.87	2153.78^{c} ± 21.43	2128.35^{bc} ± 21.43	0.004
Daily Weight Gain						
d 1-14 (g)	20.09 ± 0.33	20.10 ± 0.33	20.09 ± 0.30	20.48 ± 0.24	20.54 ± 0.27	0.660
d 15-28 (g)	48.63^{a} ± 0.59	51.02^{b} ± 0.52	50.45^{b} ± 0.52	52.16^{b} ± 0.65	51.48^{b} ± 0.58	0.007
d 29-42 (g)	71.88^{a} ± 0.93	75.42^{bc} ± 0.84	74.70^{b} ± 0.97	78.19^{c} ± 0.91	76.92^{bc} ± 0.87	0.002
d 1-42 (g)	46.87^{a} ± 0.55	48.92^{b} ± 0.72	48.40^{ab} ± 0.51	50.28^{b} ± 0.69	49.65^{b} ± 0.61	0.016
Feed Intake						
d 1-14 (g/bird)	410.02 ± 3.43	409.22 ± 3.33	408.80 ± 3.44	413.01 ± 3.39	412.53 ± 3.54	0.862
d 15-28 (g/bird)	1182.29^{a} ± 5.97	1224.51^{c} ± 6.38	1206.78^{bc} ± 7.03	1210.72^{bc} ± 6.10	1194.95^{ab} ± 7.45	0.005
d 29-42 (g/bird)	2406.15^{ab} ± 15.40	2441.20^{b} ± 14.85	2381.45^{a} ± 15.29	2369.03^{a} ± 14.67	2401.44^{ab} ± 13.83	0.034
d 1-42 (g/bird)	3998.46 ± 31.53	4074.98 ± 30.06	3997.08 ± 31.62	3992.80 ± 30.88	4008.96 ± 32.22	0.349
FCR[2]						
d 1-14	1.265 ± 0.025	1.261 ± 0.018	1.264 ± 0.025	1.256 ± 0.026	1.248 ± 0.027	0.988
d 15-28	1.736^{b} ± 0.018	1.707^{ab} ± 0.022	1.708^{ab} ± 0.015	1.658^{a} ± 0.016	1.657^{a} ± 0.014	0.025
d 29-42	2.391^{c} ± 0.042	2.311^{bc} ± 0.036	2.289^{abc} ± 0.043	2.164^{a} ± 0.036	2.229^{ab} ± 0.041	0.014
d 1-42	1.988^{b} ± 0.030	1.942^{ab} ± 0.023	1.925^{ab} ± 0.033	1.853^{a} ± 0.027	1.883^{a} ± 0.028	0.041

[a,b,c]Means in the same row with different superscripts differ significantly (P < 0.05)
[1] The results are reported as Mean ±SEM
[2] FCR = feed conversion ratio

The means of organ's weights for experimental groups are summarized in Table 3.The weight of Proventriculus, Gizzard, Liver and Bursa did not show any significant difference (*P>0.05*) between experimental groups.In agreement with our findings, it's reported that weight of Gizzard did not affect significantly by addition of prebiotic [38], probiotic [16, 28, 38, 39] and synbiotic [16, 105]. Also, it has been reported that dietary inclusion of prebiotic, probiotic and synbiotic had no significant effect on Liver weight [38, 40, 41]. In agreement with our findings, it's reported that weight of Bursa did not show any significant difference by dietary supplementation of prebiotic [38], probiotic [16,] and synbiotic [16]. In this study, the weight of Spleen increased significantly (*P<0.05*) in probiotic group compare the control group. However, Awad et al. (2009) reported that addition of probiotic and synbiotic to broilers diet did not show any significant effect on spleen weight compared with control group, whereas the weight of spleen was significantly different between probiotic and synbiotic group. It has been reported that addition of probiotics to broilers diet did not have any significant difference on spleen weight [38, 40, 41, 42].

Table 2: weight of internal organs of broiler chickens at the end of experiment[1]

	Dietary treatment					
Organ	Control	Prebiotic	Probiotic	Synbiotic	Acidifier	P Value
Proventriculus	8.42 ± 0.42	8.51 ± 0.38	9.05 ± 0.32	8.40 ± 0.40	8.22 ± 0.39	0.640
Gizzard	43.12 ± 2.55	46.15 ± 3.12	43.07 ± 2.82	44.02 ± 3.64	42.57 ± 2.22	0.913
Liver	64.77 ± 3.09	66.65 ± 3.08	61.72 ± 3.54	62.15 ± 3.13	63.92 ± 3.48	0.823
Spleen	1.87^{a} ± 0.05	1.98^{ab} ± 0.05	2.11^{b} ± 0.06	2.06^{ab} ± 0.06	1.96^{ab} ± 0.05	0.104
Bursa	2.28 ± 0.93	2.14 ± 0.09	2.36 ± 0.08	2.25 ± 0.08	2.09 ± 0.08	0.222

[a,b]Means in the same row with different superscripts differ significantly (P < 0.05)
[1] The results are reported as Mean ±SEM

Table 3: Mortality rate of broilers at the whole experimental period (percentage)

	Dietary treatment				
	Control	Prebiotic	Probiotic	Synbiotic	Acidifier
Mortality (%)	9.37	6.25	6.25	6.25	9.37

CONCLUSION

The results of this study showed that dietary inclusion of prebiotics, probiotics, synbiotics and acidifiers improved growth performance compare the control group. Among these Synbiotic had the greatest effect on growth performance compare other experimental groups. Also, experimental groups had not any significant effect on the weight of Proventriculus, Gizzard, Liver and Bursa fabrisius. Additionally, the weight of Spleen was greater for the prebiotic-supplemented group compared with acidifier-supplemented group.

REFERENCES

[1] R. Fuller, *J. Appl. Microbiol.*, **1989**, 66(5), 365-378.
[2] H. Sorum, M. Sunde, *Vet. Res.*, **2001**, 32, 227-241.
[3] V. Burgat, *Rev. Prat.*, **1999**, 41, 985-990.
[4] A. Andremont, *Ann. Fr. Anesth. Reanim.*, **2000**, 19, 395-402.
[5] G.R. Gibson, M.B. Roberfroid, *J. Nutr.*, **1995**, 125, 1401-1412.
[6] J.M.A.J. Verdonk, P. van Leeuwen, *4th Orafti Research Conference*, 12-13 Feb. **2004**, Paris, France.
[7] Y. Yusrizal, T.C. Chen, *Int. J. Poult. Sci.*, **2003**, 2(3), 214-219.
[8] H.R. Rahmani, W. Speer, *Int. J. Poult. Sci.*, **2005**, 4(9), 713-717.
[9] FAO/WHO, 2002. Joint FAO/WHO (Food and Agriculture Organization/ World Health Organization) Joint working group report on drafting. London, Ontario, **2002**, 1-11
[10] S.M.L. Kabir, M.M. Rahman, M.B. Rahman, M.M. Rahman, S.U. Ahmed, *Int. J. Poult. Sci.*, **2004**, 40, 340-347.
[11] G. Kralik, Z. Milakovic, S. Ivankovic, Acta Agric. Kapo., **2004**, 8, 23–31.
[12] J.R. Gil De Los Santos, O.B. Storch, C. Gil-Turnes, *Br. Poult. Sci.*, **2005**, 46, 494–497.
[13] A. Khakesfidi, T. Ghoorchi, *The Journal of Poultry Science.*, **2006**, 43, 296–300.
[14] K.C. Mountzouris, P. Tsistsikos, E. Kalamara, S. Nitsh, G. Schatzmayr, K. Fegeros, *Poult. Sci.*, **2007**, 86, 309-317.
[15] D.F. Apata, *J. Sci. Food Agric.*, **2008**, 88, 1253–1258.
[16] W.A. Awad, K. Ghareeb, S. Abdel-Raheem, J. Bohm, *Poul. Sci.*, **2009**, 88, 49-55.
[17] Y.H. Shim, P.L. Shinde, J.Y. Choi, J.S. Kim, D.K. Seo, J.I. Pak, B.J. Chae, I.K. Kwon, *Asian-Australasian Journal of Animal Science*, **2010**, 23, 521–529.
[18] S. Sen, S.L. Ingale, Y.W. Kim, J.S. Kim, K.H. Kim, J.D. Lohakare, E.K. Kim, H.S. Kim, M.H. Ruyu, I.K. Kwon, B.J. Chae, *Res.Vet. Sci.*, **2012**, 93(1), 264-268.
[19] D.D. Gallaher, J. Khil, *J. Nutr.*, **1999**, 129(Suppl. 7), 1483S-1487S.
[20] S.D. Boling, J.L. Snow, C.M. Parsons, D.H. Baker, *Poult. Sci.*, **2001**, 80, 783-788.
[21] E. Bonos, E. Christaki, A. Abrahim, N. Soultos, P. Florou-Paneri, Anaerobe, **2011**, 17, 436-439.
[22] R. Andrys, D. Klecker, L. Zeman, E. and Marecek, *Czech J. Anim. Sci.*, **2003**, 48, 197-206.
[23] M. Afsharmanesh, J. Pourreza, *Int. J. Poult. Sci.*, **2005**, 4, 418-424.
[24] N.S.B.M. Atapattu, C.J. Nelligaswatta, *Int. J. Poult. Sci.*, **2005**, 4, 990-993.
[25] A.N. Moghadam, J. Pourreza, A.H. Samie, *Pak. J. Biol. Sci.*, **2006**, 9, 1250-1256.
[26] Y.E. Nezhad, M. Shivazad, M., Nazeeradl, M.M.S. Babak, *J. Fac. Vet. Med. Univ. Tehran.*, **2007**. 61, 407-413.
[27] S.A. Abdel-Fattah, M.H. EI-Sanhoury, N.M. EI-Mednay, F. Abdul-Azeem, *Int. J. Poult. Sci.*, **2008**, 7, 215-222.
[28] H. A. EL-Banna, H.Y. EL-Zarba, T.A. Attia, A.A. Elatif, World Appl. Sci. J., **2010**, 11:4, 388-393.
[29] W. Awad, K. Ghareeb, J. Bohm, *Int. J. Mol. Sci*., **2008**, 9, 2205-2216.
[30] R. Chowdhury, K.M. Islam, M.J. Khan, M.R. Karimi, M.N. Haque, M. Khatun, G.M. Pesti, Poult. Sci., **2009**, 88, 1616-1622.
[31] A. Zakeri, P. Kashefi, *J. Anim. Vet. Adv*., 2011, 10, 1097-1101.
[32] L.T. Ortiz, M.L. Rodriguez, C. Alzueta, A. Rebole, J. Trevino, *Br. Poult. Sci*., **2009**, 50:3, 325-332.
[33] K.C. Mountzouris, P. Tsitrsikos, I. Palamidi, A. Arvaniti, M. Mohnl, G. Schatzmayr, K. Fegeros, *Poult. Sci.*, **2010**, 89, 58-67
[34] S.J. Jung, R. Houde, B. Baurhoo, X. Zhao, B.H. Le, *Poult. Sci.*, **2008**, 87, 1694-1699.
[35] N. Salianeh, M.R. Shirzad, S. Seifi, *J. Appl. Anim. Res*., **2011**, 39:1, 65-67.
[36] H.E. Samli, N. Senkoylu, F. Koc, M. Kanter, A. Agma, *Arch. Anim. Nutr*., **2007**, 61:1, 42-49.
[37] A. Talebi, B. Amirzadeh, B. Mokhtari, H. Gahri, *Avian Pathol*., 2008, 37:5, 509-512.
[38] O. Ashayerizadeh, B. Dastar, M. Shams Sharg, A. Ashayerizadeh, M. Mamooee, *J. Anim. Vet. Adv*., **2009**, 8, 1772-1776.
[39] B. Owens, L. Tucker, M.A. Collins, K.J. McCracken, *Br Poult Sci*., **2008**, 49:2, 202-212.
[40] R. Kalavathy, N. Abdullah, S. Jalaludin, Y.W. Ho, *Br. Poult. Sci*., **2003**, 44:1, 139-144.
[41] K.-L. Chen, W.-L. Kho, S.-H. You, R.H. Yeh, S.-W. Tang, C.-W. Hsieh, *Poult. Sci*., **2009**, 88, 309-315.
[42] A.K. Molnar, B. Podmaniczky, P. Kurti, I. Tenk, R. Glavits, GY. Virag, ZS. Szabo, *Br. Poult. Sci*., **2011**, 52:6, 658-665.