Revista Brasileira de Zootecnia
Brazilian Journal of Animal Science

ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., 46(10):805-813, 2017

Effects of dietary addition of synbiotic on the performance, carcass traits, and serum parameters of Japanese quails

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ABSTRACT - This study aimed to evaluate the effects of different levels of synbiotic (Syn) on the growth performance, carcass traits, and serum parameters of Japanese quails. A total of 1,500 (750 male and 750 female) Japanese quails were assigned to five treatments, including the control (basal diet) and basal diets with the addition of 0.1, 0.2, 0.3, and 0.4% Syn according to a completely randomized design. Each treatment in the male and female experiment groups consisted of five replicates, with 30 chicks for each replicate. The addition of Syn had no effect on body weight (BW), while the BW of female quails was higher than that of male quails at day 42. The addition of Syn reduced feed intake (FI) and improved the feed conversion ratio (FCR) (P<0.000). The daily body weight gain and FI were significantly higher in female than in male quails and Syn also improved the FCR in the overall experiment. The effect of the addition of Syn on carcass parameters (except for abdominal fat) was not determined. The addition of Syn decreased abdominal fat weight and percentage when compared with the control group. Male quails were found to have higher carcass yield, wing, neck, and other percentages than female quails. However, female quails were found to have higher breast, breast skin, abdominal fat, and visceral organ percentages. The addition of 0.1% Syn to quail ration reduced serum aspartate aminotransferase, high-density lipoprotein (HDL), total protien (TP), and albumin (ALB) levels at day 42 of the trial. The addition of Syn decreased the serum total cholesterol level. Gender was found to have an effect in that female quails were found to have higher total cholesterol, HDL, TP, and ALB levels than male quails. In both genders, the addition of Syn improved the BWG, FC, and FCR in the overall experiment, reduced abdominal fat, decreased the total cholesterol levels, improved the HDL levels, and increased the TP and ALB levels at day 42. The addition of 0.3 and/or 0.4% synbiotic has a positive effect on quails by improving performance and enhancing some serum lipids and protein parameters.

Key Words: blood parameters, carcass attributes, growth performance, synbiotics, quail

Introduction

Commercial poultry production has a short and critical intensive feeding period, ranging from the chick stage to slaughter. During this period, the gastrointestinal tract of a chick requires fast development and colonized intestinal bacteria vary frequently (Edens et al., 1997). Densely settled intestinal bacteria play a critical role in health and growth performance due to its effect on nutrition, gut morphology, and immune response of animals (Lee et al., 2002). Antibiotic supplementation had been utilized for many years to protect against pathogens in the gut and enhance performance in poultry until the EU ban took effect (Tufan et al., 2015). Research is being carried out on the use of prebiotic, probiotic, and synbiotic as feed additives instead of antibiotic in poultry nutrition (Gibson and Roberfroid, 1995; Patterson and Burkholder, 2003).

Prebiotics are functional foods that do not hydrolyze in the digestive system; they are not absorbed or digested, but increase the development or activity of a limited number of bacteria selectively in the colon and positively affect the health of humans and animals (Gibson and Roberfroid, 1995). Probiotics are alternative living biological agents for antibiotics that suppress pathogen microorganisms with bacteriocin secretion, decrease the intestine pH (Gillor et al., 2008), and improve microbial balance (Fuller, 1989), positively affecting the digestive system. It has been reported in the literature that the use of pre-probiotics in poultry improves the intestinal flora (Gibson and Roberfroid, 1995), strengthens the immune system (Hong et al., 2005), increases the digestibility of nutrients (Li et al., 2008a; Yasar and Akıncı, 2014), and enhances growth performance (Bolacali and Irak, 2017; Pelícia et al., 2004; Yasar and Akıncı, 2014).

Received: April 7, 2017
Accepted: July 26, 2017
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http://dx.doi.org/10.1590/S1806-92902017001000003

How to cite: Tufan, T. and Bolacali, M. 2017. Effects of dietary addition of synbiotic on the performance, carcass traits, and serum parameters of Japanese quails. Revista Brasileira de Zootecnia 46(10):805-813.

Synbiotics that improve fattening performance are natural ingredients and are called functional products, along with prebiotics and probiotics. Synbiotics show the biological activity that is evident when pre-probiotics are used alone at a higher level (Junqueira et al., 2009). They encourage the development and growth of beneficial bacteria in the intestines through prebiotics and probiotics, stimulate their activities, improve intestinal flora, and increase the digestibility and absorption of nutrients (Gibson and Roberfroid, 1995).

The use of Syn in poultry production encourages a healthy gut via certain possible mechanisms, such as enhancing the immune system (Hamasalim, 2016), lowering pH, and increasing protective gut mucus (Nikpiran et al., 2014), creating an antimicrobial effect (Likotrafiti et al., 2016), increasing the digestibility of nutrients (Awad et al., 2008), and enhancing nutrition performance (Elfaki and Mukhtar, 2015; Pelícia et al., 2004). In previous studies conducted on poultry, it was reported that the use of Syn enhances growth performance (Vahdatpour et al., 2011; Min et al., 2016) and carcass yield (Pelícia et al., 2004). Sahin et al. (2008) reported that the addition of Syn to broiler rations did not have any effect on total serum protein, albumin, and total cholesterol levels.

It is known that probiotics on the small intestine, prebiotics on the large intestine, and synbiotics on both small and large intestines have a positive effect (Gibson and Roberfroid, 1995; Hamasalim, 2016). The objective of this study was to determine the effects of different levels of Syn on performance, carcass traits, and blood parameters of both genders of Japanese quails.

Material and Methods

The synbiotic used in this study (SynbioticerAll™) was provided by the manufacturing company Global Nutritech LLC, Richmond, VA, USA. It included live *Saccharomyces cerevisiae* (strain NCYC R618), mannan, and glucan.

The research was conducted in Siirt, Turkey, between November and December of 2016. The research on animals was conducted according to the institutional committee on animal use (2016/09). A total of 1,500 (750 male and 750 female) one-day-old Japanese quail chicks for which two different experimental designs were designed - for male and female quails - was randomly allocated to one control group and four main groups with five pen replicates of 30 birds each. Over the experimental period, the quails were fed starter (1 to 21 days) and grower (22 to 42 days) basal diets (Table 1) formulated to meet the nutrient requirements specified by the National Research Council (NRC, 1977). The treatments were conducted as follows: control (basal diet), basal diet + 0.1% Syn, basal diet + 0.2% Syn, basal diet + 0.3% Syn, and basal diet + 0.4% Syn. The chicks in each replicate group were housed in cages with dimensions of 45.5 × 68.8 × 177 cm (width × length × height). The required heating and 24-hour lighting were provided during the study and feed and water were given *ad libitum*. The study lasted 42 days and was conducted in cages.

The body weight (BW) of birds was recorded weekly and body weight gain (BWG) was calculated daily. Weekly feed intake (FI) was determined according to the daily feed and increasing feed and weekly FI was divided by the number of the animals and seven days to calculate the daily FI. The FI was divided by BWG to calculate the FCR.

On the 42nd day of the study, 300 quails were slaughtered to determine slaughtering and carcass parameters. The quails were slaughtered from both female and male experiment groups, six quails from each replicate group and 30 from each main group. The process of slaughtering and

Table 1 - Ingredient composition and analyzed content of the nutrients in the diets used in the trial

	Diet	
	Starter	Grower
Ingredients (g kg^{-1})		
Yellow corn	450.0	527.8
Wheat	83.1	90.0
Vegetable oil	30.0	10.0
Soybean meal (48% CP)	300.0	270.0
Fish meal (64% CP)	35.0	-
Sunflower meal (32% CP)	80.0	70.0
Lime stone	9.5	12.5
Vitamin and mineral premix[1]	2.5	2.5
Salt	3.5	3.5
DCP	4.1	13.5
Antioxidant	0.8	-
D-L methionine	-	0.2
L-threonine	1.5	-
Nutritional content (g kg^{-1})		
Dry matter	900.5	898.3
Metabolic energy (kcal kg^{-1})[2]	3,005	2,905
Crude protein	239.0	200.0
Crude fat	46.0	28.0
Crude fiber	44.2	44.5
Crude ash	56.2	61.0
Calcium	8.2	9.2
P	3.7	3.8
Na	2.0	1.8
Cl	2.8	2.6
Methionine + cysteine	8.5	7.1
Lysine	13.0	10.3
Threonine	10.6	7.6
Tryptophan	3.1	2.7

CP - crude protein.
[1] Supplied the following per kilogram of diet: 13,000 IU vitamin A; 3,500 IU vitamin D3; 100 mg vitamin E; 3 mg vitamin K3; 3 mg vitamin B1; 8 mg vitamin B2; 6 mg vitamin B6; 30 mg vitamin B12; 30 mg niacin; 8 mg calcium-D-panthotenate; 2 mg folic acid; 70 mg vitamin C; 70 mg D-biotin; 200 mg choline chloride; 2 mg canthaxanthin; 0.75 mg apo carotenoic acid esther; 120 mg Mn; 100 mg Zn; 90 mg Fe; 16 mg Cu; 1.5 mg I; 0.75 mg Co; 0.30 mg Se.
[2] Calculated according to NRC (1977) table values.

the separation into carcass parts were performed according to the method of Genchev and Mihaylov (2008). Carcass parameters were determined as hot and cold carcass, leg, breast, wing, back, neck, other, and breast skin weights/percentages. The parameters of the visceral organs were determined according to the heart, liver, gizzard, intestine weight, and abdominal fat weight/percentage.

To determine the serum parameters, two blood samples from each subgroup and 10 blood samples from each main group were taken in anticoagulant-free tubes from the male and female study groups at days 21 and 42 of the study. The blood samples were centrifuged at 3,000 rpm for 10 min, and the serum was kept at −20 °C until the analyses were conducted. The aspartate aminotransferase (AST), total cholesterol, high-density lipoprotein (HDL), total protein (TP), and albumin (ALB) levels in the serum were analyzed with an auto analyzer (ADVIA 1800 Chemistry System).

Data were analyzed using a factorial model of the general linear model procedure of Minitab software (Minitab, 2017). The statistical model included the feed additive (Syn) and gender and their interaction effect. Differences within a significant effect were separated using Duncan's Multiple Range Test. Data points bearing different letters were considered significantly different at $P \leq 0.05$.

Results

The interaction between Syn and gender had no effect ($P>0.05$) on hatching at days 7, 14, and 42, but significantly influenced the BW at days 21, 28, and 35 (Table 2). The lowest BW was detected in the female control group at day 21 ($P<0.039$). The highest BW was determined in the female group fed 0.2% Syn at day 28 ($P<0.024$) and in the female group fed 0.1% Syn at day 35 ($P<0.000$). In terms of the addition of Syn in the study, the lowest BW was detected in the control group at day 21 ($P<0.014$) and in the group fed 0.3% Syn at days 28 and 35 ($P<0.008$ and $P<0.000$, respectively). It was determined that gender was effective on liveweight in later periods after day 21 ($P<0.05$). While BW was significantly higher in male quails than in female quails at day 21 ($P<0.007$), it was significantly higher in female quails than in male quails at days 28, 35, and 42 ($P<0.000$).

The interaction between Syn and gender had an effect on BWG, FI, and FCR of the birds at all rearing stages (except for the starter period of the FI) ($P<0.05$; Table 3). The highest BWG was detected in the male group fed 0.1% Syn in the starter period ($P<0.028$) and in the female group fed 0.1% Syn in the grower period and throughout the

Table 2 - Effects of dietary supplementation of synbiotic (Syn) on live body weights of quails at various periods (g)[1]

Group	Gender	Hatching	7th day	14th day	21st day	28th day	35th day	42nd day
0.4% Syn	Male	7.65	29.30	62.70	108.42ab	140.61cd	161.48d	174.67
	Female	7.66	29.44	61.94	107.44abc	147.62b	181.46c	204.47
0.3% Syn	Male	7.72	28.69	63.21	107.91ab	137.68d	155.63d	171.69
	Female	7.71	28.66	63.22	108.60ab	147.79b	184.38b	207.70
0.2% Syn	Male	7.59	28.66	63.83	107.70abc	139.31cd	160.11c	173.04
	Female	7.62	28.65	63.57	106.80bcd	152.69a	186.14b	206.64
0.1% Syn	Male	7.65	28.64	65.70	109.70a	141.79c	162.25c	172.75
	Female	7.64	28.62	63.25	105.40cd	150.08ab	190.53a	208.81
Control	Male	7.65	28.11	64.27	106.35bcd	139.17cd	162.23c	171.09
	Female	7.63	28.06	64.06	104.87d	149.80ab	190.38a	207.24
SEM		0.04	0.27	1.01	0.77	0.97	0.94	1.22
0.4% Syn		7.65	29.37	62.32	107.93a	144.12ab	171.47bc	189.57
0.3% Syn		7.72	28.68	63.22	108.26a	142.73b	170.00c	189.69
0.2% Syn		7.60	28.66	63.70	107.25a	146.00a	173.12b	189.84
0.1% Syn		7.64	28.63	64.48	107.55a	145.93a	176.39a	190.78
Control		7.64	28.08	64.17	105.61b	144.49ab	176.31a	189.17
SEM		0.03	0.19	0.71	0.54	0.68	0.67	0.86
Male		7.65	28.68	63.94	108.02	139.71	160.34	172.65
Female		7.65	28.69	63.21	106.62	149.60	186.58	206.97
SEM		0.02	0.12	0.45	0.34	0.43	0.42	0.54
Source of variation								
Synbiotic		0.158	0.001	0.247	0.014	0.008	0.000	0.749
Gender		0.988	0.971	0.258	0.007	0.000	0.000	0.000
Syn × gender		0.972	0.997	0.744	0.039	0.024	0.000	0.054

SEM - standard error of mean.
[1] Means were obtained from five replicate cages.
a-d - Means within a column with different letters are significantly different at the level shown.

trial (P<0.003 and P<0.048, respectively). The addition of Syn to quail rations increased BWG in the starter period (P<0.042). The best performance was in the control group in the grower period (P<0.007). It was determined that the addition of Syn between 1-42 days had no effect (P>0.05) on BWG. While male quails had a higher BWG than female quails in the starter period (P<0.019), female quails had a higher BWG than male quails in the grower and overall period (P<0.000).

The highest FI was determined in the female group fed 0.2% Syn in the grower period and throughout the trial (P<0.000). The addition of Syn reduced FI in all periods (P<0.000). Female quails had a higher FI than male quails in the grower period and throughout the trial (P<0.000). The addition of Syn to quail rations improved the FCR in both male and female quails in all breeding periods of the study (P<0.000). While the FCR improved for males in the starter period (P<0.000), it improved for females in the grower period (P<0.017) and throughout the trial (P<0.000).

There were no effects of the interaction between Syn and gender on the weights and percentages of carcass parameters (P>0.05) (Tables 4 and 5). The addition of Syn to quail rations had no effect on other carcass weights and percentages except for abdominal fat weight and percentage (P>0.05), in which it reduced abdominal fat weight (P<0.001) and percentage (P<0.000). The slaughter weight, hot carcass, cold carcass, leg, breast, breast skin, and abdominal fat weights of female quails were higher than those of male quails (P<0.000). The hot carcass (P<0.000), cold carcass (P<0.000), other (P<0.006), wing (P<0.020), and neck (P<0.008) percentages were higher in male quails than in female quails. However, female quails were found to have higher breast, breast skin, and abdominal fat percentages (P<0.000).

There were no effects of feed additive (Syn) and the interaction between Syn × gender on the percentage of the visceral organs (P>0.05) (Table 6). Female quails were found to have higher visceral organ percentages than male quails (P<0.000).

The Syn × gender interaction had no effect on AST, serum total cholesterol, and HDL (P>0.05), but had an effect on TP (P<0.029) and ALB (P<0.046) at day 21 (Table 7). The highest TP and ALB were in the male group fed 0.4% Syn. The effect of feed additive on AST, total cholesterol, HDL, and TP was not observed at day 21. Female quails

Table 3 - Effect of adding various levels of synbiotic (Syn) to the rations of male and female quails on BWG (g/day), FI (g/day), and FCR (g/g)[1]

Group	Gender	BWG 1-21 days	BWG 22-42 days	BWG 1-42 days	FI 1-21 days	FI 22-42 days	FI 1-42 days	FCR 1-21 days	FCR 22-42 days	FCR 1-42 days
0.4% Syn	Male	4.80ab	3.16d	3.98ab	9.51	22.17def	15.84e	1.98c	7.03ab	3.98bc
	Female	4.75bc	4.62c	4.69ab	9.85	23.24f	16.55d	2.08b	5.03e	3.53f
0.3% Syn	Male	4.77ab	3.04d	3.91b	9.74	21.98ef	15.86e	2.04c	7.24a	4.07b
	Female	4.81a	4.72bc	4.76a	9.91	24.85c	17.38c	2.06bc	5.27de	3.65ef
0.2% Syn	Male	4.77ab	3.11d	3.94b	9.95	21.13fg	15.54ef	2.09b	6.80b	3.95bc
	Female	4.72bc	4.75bc	4.74a	9.84	27.93a	18.88a	2.08b	5.87c	3.99bc
0.1% Syn	Male	4.86a	3.00d	3.93b	10.03	20.36g	15.19f	2.06bc	6.79b	3.87cd
	Female	4.66c	4.93a	4.79a	9.80	26.40b	18.10b	2.10b	5.37de	3.78ed
Control	Male	4.70bc	3.08d	3.89b	10.56	22.38de	16.47d	2.24a	7.27a	4.23a
	Female	4.63a	4.88ab	4.75a	10.43	26.96ab	18.70a	2.26a	5.53cd	3.93bc
SEM		0.05	0.05	0.04	0.18	0.36	0.18	0.03	0.12	0.05
0.4% Syn		4.78a	3.89	4.33	9.68b	22.71b	16.19d	2.03b	6.03b	3.76c
0.3% Syn		4.79a	3.88	4.33	9.83b	23.41b	16.62c	2.05b	6.26ab	3.86b
0.2% Syn		4.75a	3.93	4.34	9.89b	24.53a	17.21b	2.08b	6.34a	3.97b
0.1% Syn		4.76a	3.96	4.36	9.91b	23.38b	16.64c	2.08b	6.08b	3.82b
Control		4.67b	3.98	4.32	10.49a	24.67a	17.58a	2.25a	6.40a	4.08a
SEM		0.03	0.04	0.03	0.13	0.25	0.12	0.02	0.08	0.03
Male		4.78	3.08	3.93	9.96	21.60	15.78	2.08	7.03	4.02
Female		4.71	4.78	4.75	9.96	25.88	17.92	2.12	5.41	3.78
SEM		0.02	0.02	0.02	0.08	0.16	0.08	0.01	0.05	0.02
Source of variation										
Synbiotic		0.042	0.240	0.885	0.000	0.000	0.000	0.000	0.017	0.000
Gender		0.019	0.000	0.000	0.944	0.000	0.000	0.047	0.000	0.000
Syn × gender		0.028	0.003	0.048	0.497	0.000	0.000	0.039	0.000	0.000

BWG - daily body weight gain; FI - feed intake; FCR - feed conversion ratio; SEM - standard error of mean.
[1] Means were obtained from five replicate cages.
a-g - Means within a column with different letters are significantly different at the level shown.

were found to have lower AST, total cholesterol, and HDL levels than male quails.

The Syn × gender interaction had an effect on AST (P<0.000), serum total cholesterol (P<0.002), HDL (P<0.001), TP (P<0.007), and ALB (P<0.007) at day 42. The lowest total cholesterol level was found in the male group fed 0.2% Syn and the highest serum HDL level in the female group fed 0.4% Syn. The highest TP and ALB levels were found in the female group fed 0.4% Syn. The addition of 0.1% Syn to quail ration reduced serum AST, HDL, TP, and ALB levels (P<0.000). The addition of Syn to quail ration also reduced the total cholesterol level (P<0.000). Gender had no effect on the serum AST level (P>0.05), but had an effect on total cholesterol (P<0.002), HDL (P<0.000), TP (P<0.000), and ALB (P<0.000) levels. Female quails were found to have higher total cholesterol, HDL, TP, and ALB levels than male quails.

Discussion

The objective of the present study was to study the efficacy of Syn on the performance, carcass characteristics, and serum parameters of Japanese quails. In the current study, the dietary inclusion of Syn increased BW of 21-day-old chicks and increased BWG and decreased FI and FCR during the starter period (1 to 21 days) when compared with the control group. In the present study, it was observed that the use of Syn as an additive in the early period improved the fattening performance, but there was no dose response. Research shows that the use of Syn, prebiotics, probiotics, and combination of Syn as feed additives improves growth performance and health by regulating intestinal microflora (Gibson and Roberfroid, 1995; Li et al., 2008b). A number of researchers have previously demonstrated the useful effect of Syn on BW, BWG, and FCR in poultry in the early period of chicks (Dizaji et al., 2012; Yasar and Akıncı, 2014).

The addition of a Syn supplement in the quail diet improved FCR in the grower and overall periods, which is consistent with the findings of Dizaji et al. (2012) and Yasar and Akıncı (2014). The Synbiotic feed additive reduced FI in the grower period, which is consistent with the findings of Dizaji et al. (2012), but inconsistent with the findings of Yasar and Akıncı (2014). In the present study, it was found that the improvement in the FCR depended on the dose of Syn used as a feed additive (Elfaki and Mukhtar, 2015).

Body weight, at day 21, and BWG and FCR, during the starter period (1 to 21 days), of male improved compared with female quails. On the contrary, the gender of quails

Table 4 - Effect of dietary synbiotic (Syn) supplementation on weights of carcass traits of quails (g)[1]

Group	Gender	Slaughter	Hot carcass	Cold carcass	Leg	Breast	Wing	Back	Neck	Other	Breast skin	Abdominal fat
0.4% Syn	Male	175.45	133.30	130.22	29.72	47.43	10.85	12.63	9.33	16.79	3.55	1.57
	Female	203.25	143.71	136.87	31.74	49.90	11.28	12.55	9.88	17.29	4.25	1.92
0.3% Syn	Male	173.80	133.09	128.94	29.36	46.00	11.06	11.79	9.86	17.31	3.57	1.54
	Female	203.72	142.57	136.51	31.68	50.36	10.97	12.41	9.10	17.77	4.23	1.83
0.2% Syn	Male	173.59	132.03	128.26	29.71	45.94	11.03	12.05	9.75	16.55	3.22	1.33
	Female	203.27	138.57	134.01	30.27	49.21	10.83	12.55	9.66	17.13	4.37	1.96
0.1% Syn	Male	173.19	133.23	129.64	29.35	46.43	11.05	11.81	9.91	17.42	3.66	1.34
	Female	205.26	143.26	138.85	32.05	51.20	11.79	12.27	9.71	17.48	4.35	1.98
Control	Male	175.24	134.61	129.71	29.67	47.39	10.84	11.65	9.22	17.14	3.81	1.92
	Female	202.33	137.45	131.66	30.38	48.09	10.77	12.15	9.47	16.92	3.89	2.38
SEM		1.80	2.23	2.22	0.63	0.96	0.32	0.37	0.25	0.39	0.21	0.13
0.4% Syn		189.35	138.50	133.54	30.73	48.66	11.06	12.59	9.60	17.04	3.90	1.75b
0.3% Syn		188.76	137.83	132.73	30.52	48.18	11.01	12.10	9.48	17.54	3.90	1.68b
0.2% Syn		188.43	135.30	131.13	29.99	47.58	10.93	12.30	9.71	16.84	3.79	1.64b
0.1% Syn		189.22	138.25	134.25	30.70	48.82	11.42	12.04	9.81	17.45	4.01	1.66b
Control		188.79	136.03	130.69	30.02	47.74	10.81	11.90	9.35	17.03	3.85	2.15a
SEM		1.27	1.58	1.57	0.45	0.68	0.22	0.26	0.17	0.27	0.15	0.09
Male		174.25	133.25	129.35	29.56	46.64	10.97	11.99	9.61	17.04	3.56	1.54
Female		203.57	141.11	135.58	31.22	49.75	11.13	12.38	9.56	17.32	4.22	2.01
SEM		0.81	1.00	0.99	0.28	0.43	0.14	0.17	0.11	0.17	0.09	0.06
Source of variation												
Synbiotic		0.987	0.514	0.441	0.626	0.628	0.379	0.390	0.348	0.308	0.885	0.001
Gender		0.000	0.000	0.000	0.000	0.000	0.425	0.093	0.752	0.264	0.000	0.000
Syn × gender		0.670	0.398	0.564	0.324	0.227	0.520	0.896	0.096	0.814	0.169	0.584

SEM - standard error of mean.
[1] Means were obtained from six quails of each replicate group and 30 quails of each main group.
a,b - Means within a column with different letters are significantly different at the level shown.

plays a role in their fattening performance. Kul et al. (2006) reported that females had a higher BW at day 21 and higher BWG between days 14-21 compared with males. Ayasan et al. (2000) reported that gender had no effect on quail BW at day 21 nor on the FI and FCR between days 1 and 21. Kul et al. (2006) reported that females had a higher BW at day 21 and higher BWG between days 14 and 21 compared with males.

In the present study, female quails showed better improvement in the BWG and FCR in the grower period of this study than male quails, which is consistent with the findings of some studies (Ayoola et al., 2014; Kul et al., 2006). The increase in the FI was found to be incompatible with the results of Ayoola et al. (2014). The improvement in the BWG throughout the experiment was shown to be similar to the results of Kul et al. (2006). These authors found that the FI and FCR of female quails were not affected between 14 and 42 days compared with those of male quails, which is inconsistent with the results of the current study. Ayasan et al. (2000) reported that female quails had higher BWG at day 35 compared with male quails and that gender had no effect on the FI and FCR between days 1 and 35. In the present study, the growth parameters were inconsistent with those of previous findings. This may be attributed to the use of different strains and doses of probiotics and prebiotics in combination with Syn or different experiment conditions and durations.

The interaction between the Syn feed additive and gender significantly influenced BWG, FI, and FCR throughout the experiment (1-42 days). In this study, the improvement in the BWG, FI, and FCR of male quails in the period of the experiment (1-42 days) is caused by the growth-promoting effect of Syn. The improvement in growth performance found in this study may be associated with the dose of the feed additive. The positive effects of probiotics and prebiotics on intestinal flora are well known. In this study, the improvement in growth performance may be associated with Syn assistance in digestion and absorption, such as with protein (Hamasalim, 2016). This improvement in growth performance may be explained by the positive effect of the use of Syn as an additive on protein metabolism in the present study. In terms of performance, synbiotics were effective in improving the growth of poultry, which corresponded to the effect of supplementation of either probiotics or prebiotics in the diet of chickens.

Table 5 - Effect of dietary synbiotic (Syn) supplementation on relative organ ratio (percentage of cold carcass mass) of male and female quails (%)[1]

Group	Gender	Hot carcass	Cold carcass	Leg	Other	Wing	Breast	Back	Neck	Breast skin	Abdominal fat
0.4% Syn	Male	76.00	74.24	22.83	12.90	8.33	36.41	9.70	7.16	2.72	1.21
	Female	70.62	67.26	23.17	12.62	8.24	36.45	9.17	7.26	3.10	1.41
0.3% Syn	Male	76.58	74.20	22.76	13.44	8.57	35.67	9.14	7.65	2.77	1.19
	Female	69.96	66.98	23.20	13.04	8.02	36.89	9.10	6.67	3.10	1.35
0.2% Syn	Male	76.06	73.88	23.17	12.90	8.59	35.83	9.40	7.60	2.51	1.03
	Female	68.13	65.88	22.56	12.78	8.09	36.72	9.36	7.23	3.26	1.46
0.1% Syn	Male	76.93	74.85	22.65	13.43	8.52	35.82	9.12	7.65	2.82	1.03
	Female	69.80	67.62	23.06	12.60	8.48	36.86	8.84	7.01	3.14	1.42
Control	Male	76.82	74.04	22.87	13.20	8.35	36.53	9.01	7.12	2.93	1.48
	Female	67.89	65.03	23.06	12.85	8.20	36.49	9.22	7.24	2.95	1.80
SEM		0.73	0.72	0.20	0.22	0.18	0.27	0.25	0.21	0.14	0.10
0.4% Syn		73.31	70.75	23.00	12.76	8.28	36.43	9.43	7.21	2.91	1.31b
0.3% Syn		73.27	70.59	22.98	13.24	8.30	36.28	9.12	7.16	2.94	1.27b
0.2% Syn		72.09	69.88	22.87	12.84	8.34	36.28	9.38	7.42	2.88	1.24b
0.1% Syn		73.36	71.24	22.85	13.02	8.50	36.34	8.98	7.33	2.98	1.23b
Control		72.35	69.53	22.96	13.03	8.27	36.51	9.11	7.18	2.94	1.64a
SEM		0.51	0.51	0.14	0.16	0.13	0.19	0.18	0.15	0.10	0.07
Male		76.48	74.24	22.86	13.18	8.47	36.05	9.27	7.43	2.75	1.19
Female		69.28	66.55	23.01	12.78	8.20	36.68	9.14	7.08	3.11	1.49
SEM		0.32	0.32	0.09	0.10	0.08	0.12	0.11	0.09	0.06	0.04
Source of variation											
Synbiotic		0.242	0.131	0.922	0.241	0.696	0.890	0.331	0.675	0.974	0.000
Gender		0.000	0.000	0.219	0.006	0.020	0.000	0.405	0.008	0.000	0.000
Syn × gender		0.156	0.612	0.051	0.591	0.464	0.067	0.650	0.058	0.174	0.574

SEM - standard error of mean.
[1] Means were obtained from six quails of each replicate group and 30 quails of each main group.
a,b - Means within a column with different letters are significantly different at the level shown.

Table 6 - Effect of dietary synbiotic (Syn) supplementation on relative organ percentage in male and female quails (g)[1]

Group	Gender	Heart	Liver	Intestine	Gizzard
0.4% Syn	Male	0.87	1.45	2.62	1.55
	Female	0.84	2.49	3.34	1.93
0.3% Syn	Male	0.87	1.58	2.75	1.62
	Female	0.84	2.36	3.39	1.73
0.2% Syn	Male	0.85	1.56	2.51	1.72
	Female	0.81	2.40	3.30	1.82
0.1% Syn	Male	0.86	1.91	2.63	1.67
	Female	0.73	2.31	3.25	1.88
Control	Male	0.89	1.74	2.85	1.77
	Female	0.79	2.50	3.32	1.77
SEM		0.04	0.14	0.18	0.09
0.4% Syn		0.85	1.97	2.98	1.74
0.3% Syn		0.85	1.97	3.07	1.67
0.2% Syn		0.83	1.98	2.90	1.77
0.1% Syn		0.80	2.11	2.94	1.78
Control		0.84	2.12	3.09	1.77
SEM		0.03	0.10	0.13	0.06
Male		0.87	1.65	2.67	1.66
Female		0.80	2.41	3.32	1.82
SEM		0.02	0.06	0.08	0.04
Source of variation					
Synbiotic		0.539	0.638	0.818	0.731
Gender		0.006	0.000	0.000	0.004
Syn × gender		0.506	0.238	0.927	0.244

SEM - standard error of mean.
[1] Means were obtained from six quails of each replicate group and 30 quails of each main group.

The fact that the addition of Syn had no effect on other internal organs and carcass parameters, except for abdominal fat weight and percentage, is consistent with other studies on quails (Sahin et al., 2008; Sharifi et al., 2011) and broilers (Elfaki and Mukhtar, 2015; Saiyed et al., 2015). Moreover, the fact that the addition of Syn reduced abdominal fat weight and percentage is consistent with the results of Saiyed et al. (2015) and Mokhtari et al. (2015). Fattening is an undesirable condition in commercial poultry production; abdominal fat is one of the carcass parameters that is not consumed. We found that the addition of Syn reduced abdominal fat, which shows that it can be used as an alternative additive in commercial poultry production in which fattening caused by high-energy rations is seen.

The result of the current study is consistent with the outcome of Alkan et al. (2013), who found that carcass yield was higher in male quails than in females, but inconsistent with the finding of Alkan et al. (2013) that breast, wing, and abdominal fat percentages were higher in female quails than in males. In accordance with the results of the present study, Ojedapo and Amao (2014) found that breast percentage was higher in female quails than in males. In the current study, supplementation with Syn decreased the abdominal

Table 7 - Effects of synbiotic (Syn) supplementation on some quail blood serum parameters at days 21 and 42[1]

Group	Gender	Day 21					Day 42				
		AST (U/L)	CHOL (mg/dL)	HDL (mg/dL)	TP (g/dL)	ALB (g/dL)	AST (U/L)	CHOL (mg/dL)	HDL (mg/dL)	TP (g/dL)	ALB (g/dL)
0.4% Syn	Male	250.00	120.17	75.45	2.02a	0.98a	250.17ab	101.33d	66.60c	2.42b	1.10b
	Female	140.50	86.83	47.30	1.35c	0.62bc	268.00a	113.00cd	147.37a	3.42a	1.55a
0.3% Syn	Male	155.50	109.67	65.73	1.57bc	0.73abc	230.67d	93.67d	45.22d	2.07bc	0.92bc
	Female	168.67	116.00	58.42	1.80abc	0.85ab	166.17d	110.17cd	131.60a	1.80bcd	0.80bc
0.2% Syn	Male	199.17	133.17	64.28	1.57ab	0.70bc	188.50cd	87.33d	42.65d	1.53cd	0.67cd
	Female	128.67	89.00	50.12	1.30c	0.60bc	213.17bc	136.83bc	89.88b	1.92bc	0.82bc
0.1% Syn	Male	155.17	108.67	63.23	1.48bc	0.67bc	150.83d	107.00cd	28.70d	1.20d	0.48d
	Female	143.67	91.33	50.53	1.32c	0.55c	100.67e	158.50b	71.35bc	1.55cd	0.68cd
Control	Male	151.83	107.33	63.40	1.40bc	0.63bc	167.67d	189.50a	42.28d	1.28d	0.48d
	Female	147.17	97.17	54.90	1.40c	0.63bc	231.00abc	165.50ab	77.47bc	2.33b	1.08b
SEM		26.334	11.391	5.731	0.138	0.078	14.67	14.67	14.67	6.94	0.20
0.4% Syn		195.25	103.50	61.38	1.68	0.80	259.08a	107.17c	106.98a	2.92a	1.33a
0.3% Syn		162.08	112.83	62.08	1.68	0.79	198.42b	101.92c	88.41b	1.93b	0.86b
0.2% Syn		163.92	111.08	57.20	1.43	0.65	200.83b	112.08c	66.27c	1.73b	0.74bc
0.1% Syn		149.42	100.00	56.88	1.40	0.61	125.75c	132.75b	50.03d	1.38c	0.58c
Control		149.50	102.25	59.15	1.40	0.63	199.33b	177.50a	59.88cd	1.81b	0.78bc
SEM		18.62	8.05	4.05	0.10	0.06	10.38	7.09	4.90	0.14	0.07
Male		182.33	115.80	66.42	1.61	0.74	197.57	115.77	45.09	1.70	0.73
Female		145.73	96.07	52.25	1.43	0.65	195.80	136.80	103.53	2.20	0.99
SEM		11.78	5.09	2.56	0.06	0.04	6.56	4.48	3.10	0.09	0.04
Source of variation											
Synbiotic		0.410	0.738	0.850	0.066	0.053	0.000	0.000	0.000	0.000	0.000
Gender		0.033	0.009	0.000	0.052	0.065	0.850	0.002	0.000	0.000	0.000
Syn × gender		0.123	0.216	0.389	0.029	0.046	0.000	0.002	0.001	0.007	0.007

AST - aspartate aminotransferase; CHOL - cholesterol; HDL - high-density lipoprotein; TP - total protein; ALB - albumin; SEM - standard error of mean.
[1] Means were obtained from two quails of each replicate group and 10 quails of each main group.
a-e - Means within a column with different letters are significantly different at the level shown.

fat weight and percentage in the male group compared with the control group. In accordance with the present results, Mokhtari et al. (2015) established that significantly reduced abdominal fat was observed with broiler diets, depending on the addition of Syn. According to Beserra et al. (2015), the administration of Syn is efficient in improving lipid profiles.

Studies on quails have found that female quails had higher rates of heart, liver, and stomach than male quails, which is consistent with the current study (Alkan et al., 2013; Ojedapo and Amao, 2014).

Blood parameters are important for observing metabolic changes in an organism. The fact that the use of Syn as a feed additive had no effect on AST, total cholesterol, HDL, TP, and ALB levels at day 21 is consistent with the result of Sharifi et al. (2011). The fact that the addition of 0.4% Syn at day 42 increased the AST level is similar to the result of Vahdatpour et al. (2011). However, the addition of 0.1% Syn reduced the AST level, being inconsistent with the results of Cakir et al. (2008) and Vahdatpour et al. (2011). The addition of Syn reduced total cholesterol level (Mousa et al., 2014) and increased the HDL level (Sharifi et al., 2011), which is consistent with the results of this study. The supplementation of Syn increased the serum HDL level which is the "good" cholesterol and decreased the abdominal fat percentage, showing positive effect of Syn on the lipid mechanism. Although the effect mechanisms of probiotics and prebiotics are not well known, it is known that they have a regulatory effect on lipid and cholesterol metabolism (Gibson and Raberfroid, 1995; Hamasalim, 2016). Probiotic and prebiotic supplementations that decrease absorption in the gastrointestinal tract and/or the synthesis of cholesterol in the liver can lead to a reduction in the serum cholesterol of broiler chickens fed probiotic- and prebiotic-supplemented diets (Mohan et al., 1996). Contrary to these results, some other studies have reported that this does not have an effect on the total cholesterol and HDL levels (Sahin et al., 2008; Sharifi et al., 2011). The addition of Syn increased the TP and ALB levels, which is consistent with the results of Tufan et al. (2015). In the present study, an improvement in the serum protein levels of the study groups, which is associated with dosage, was observed. The high TP and ALB levels of male quails in the groups fed 0.3 and 0.4% Syn and of female quails in the group fed 0.4% Syn may be associated with the positive effect of the addition of Syn on protein metabolism. However, the manner in which Syn affects protein metabolism is not fully known. In contrast to the present results, some studies have reported that adding Syn does not affect the TP and ALB levels (Sahin et al., 2008; Sharifi et al., 2011).

Conclusions

The addition of 0.3 and/or 0.4% synbiotic has a positive effect on quails by improving performance and enhancing some serum lipids and protein parameters.

Acknowledgments

The authors give special thanks to Asst. Prof. Kivanc Irak for his assistance in the serum biochemistry analysis.

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