Effect of dietary yeast autolysate on performance, slaughter, and carcass characteristics, as well as blood parameters, in quail of both genders*

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Abstract

This study was conducted to determine the effects of dietary yeast autolysate *(Saccharomyces cerevisiae)* on performance, slaughter and carcass characteristics, as well as blood parameters, in Japanese quail of both genders. A total of 1000 (500 males and 500 females) one-day-old Japanese quail *(Coturnix coturnix japonica)* were randomly allocated to one control group and four dietary groups (supplemented with 1, 2, 3, and 4% yeast autolysate) per gender, each containing 100 quail. Each dietary group was then divided into five replicate groups of 20 chicks. During the study (from 1st to 42nd day), quails fed dietary treatments supplemented with yeast autolysate had higher live bodyweight (LBW) and average daily live weight gain (ADG) than the control group, and the dietary supplementation of 2% yeast autolysate reduced feed intake (FI) and feed conversion rate (FCR) for both genders. The highest carcass yield was observed in trial 1% in male quail (P <0.01), and the control of female (P <0.05). The lowest abdominal fat percentage was observed in trial 1% and 2% of male (P <0.05), and trials 2% and 3% in female quail (P <0.01). The highest breast percentage was observed in the trial 2% of female quail. Cholesterol was significantly lower in trial 2% of male (P <0.001) on day 42. Additionally, aspartate aminotransferase (AST) (P <0.001), alkaline phosphatase (ALP) (P <0.001) and albumin (ALB) (P <0.05) concentrations in male quail were statistically different among the groups on day 42. In general, good performance and reduced abdominal fat percentage and cholesterol level were observed in the group supplemented with 2% yeast autolysate. In this study, it was concluded that the addition of 2% yeast autolysate to diet could be used as a performance enhancer for quail in the first 42 days of life.

Keywords: Carcass attributes, carcass percentages, growth, sex
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Introduction

The use of antibiotics as a performance enhancer in poultry rations has been banned in European Union countries since 2006 (Castanon, 2007). Therefore, numerous studies in recent years have examined the use of yeast and yeast products, such as inactive dry yeast, yeast culture, yeast autolysate, yeast cell wall, and live yeast, as natural growth and performance enhancers as alternatives to antibiotics in poultry diets (Bonos *et al*., 2010a; Vahdatpour *et al*., 2011; Aydin & Aydin, 2012; Mousa *et al*., 2014).

S. cerevisiae (also known as 'baker's yeast'), which is obtained from the fermentation of malted grains, is one of the most common yeast species that are added to the diet (Rezaeipour *et al*., 2012). Some live yeasts, such as *S. cerevisiae* and *Kluyveromyces marxianus,* are probiotics (Gaggìa *et al*., 2010; Duarte *et al*., 2012). However, yeast cell wall, which is obtained from inactive yeast, is prebiotic (Charalampopoulos & Rastall, 2009; Nikpiran *et al*., 2013). Yeast autolysate, which is a good source of nutrients, such as proteins, vitamins, fibre, and micronutrients, consists of ruptured or lysed cells, and includes intracellular and cell wall sections (Stone, 1998). Yeast cell wall contains β-glucans, mannan oligosaccharides (MOS), proteins, lipids, and chitin. Mannan oligosaccharides, which are derived from the outer cell wall, shift the gastrointestinal microflora balance towards

beneficial organisms (Spring *et al*., 2000). Moreover, it has been found that MOS and β-glucans have performance-enhancing properties when used as feed additives for livestock (Rozeboom *et al*., 2005).

Yeast could be used in poultry feed as an alternative to antibiotic-based drugs for performance enhancement (Stanley *et al*., 2004). Previous studies have shown that the addition of inactivated yeast to poultry feed increases live weight gain (Onifade *et al*., 1999), enhances food utilization (Firman *et al*., 2013), reduces abdominal fat (Yalçin *et al*., 2013), has an antimicrobial effect (Van Alfen, 2014), and supports the immune system (Silva *et al*., 2009). However, some studies have reported that *S. cerevisiae* supplementation does not affect poultry performance parameters and carcass characteristics (Aydin & Aydin, 2012; Rezaeipour *et al*., 2012).

Quail, which are meat and egg producers and are resistant to pathogens, have recently attracted attention in the poultry sector, as a result of these traits and the growing popularity of breeding these birds. Given the characteristics of yeast autolysate and the increasing role of quail in the poultry industry, the present study was conducted to determine the effects of dietary yeast autolysate on performance, slaughter, and carcass characteristics, as well as blood parameters, in Japanese quail of both genders.

Materials and Methods

All animal-use protocols were carried out in accordance with Directive 2010/63/EU of the European Parliament and Council of 22 September 2010 on the protection of animals used for scientific purposes (EUD, 2010). Research was conducted according to the institutional committee on animal use (protocol number 2016/07).

A total of 1000 (500 females and 500 males) one-day-old Japanese quail *(Coturnix coturnix japonica)* were randomly allocated to one control group and four dietary groups per gender, each containing 100 chicks. Each dietary group was then divided into five replicate groups of 20 chicks.

The yeast autolysate (InteWall, *S. cerevisiae*, NCYC R 625, Integro Food and Feed Manufacturing Company, İstanbul, Turkey) that was used as a prebiotic in this study consists of 92% dry matter, 40% crude protein, and 32% MOS and β-glucans derived from yeast *S. cerevisiae* cell wall. The study was conducted over 42 days, the first 21 days being the starter period, and the last 21 being the grower period. The quail were initially fed a prepared basal diet (days 1–21) and then a grower diet (days 22–42) (Table 1). The basal diets were supplemented with yeast autolysate at levels of 0% (control), 1% (trial 1%), 2% (trial 2%), 3% (trial 3%), and 4% (trial 4%). The diets were offered *ad libitum* in mashed form, and water was available at all times during the experimental period. The chicks of all replicate groups were housed in cages measuring 45.5 × 68.8 × 30.0 cm in width, length, and height, respectively. The average temperature of the pens was 37 ± 1 °C for the first three days, and was then incrementally lowered to an average of 25 ± 1 °C. This temperature was maintained up to the day of slaughter (day 42). The illumination consisted of continuous lighting throughout the study period.

The raw nutrient contents of the mixed feedstock used in the study were determined in accordance with AOAC (2000) in the Laboratory for Animal Nutrition and Nutritional Diseases at the School of Veterinary Medicine of Siirt University.

Throughout the study, the number of dead quail was checked and recorded daily. The LBW of the chicks were recorded at hatching and then once weekly throughout the study. The difference between consecutive weekly weighing results was divided by seven and by the number of animals to calculate the ADG. Overall weekly net feed consumption was calculated by measuring the daily leftover feed. Weekly feed consumption was divided by seven and by the number of animals to calculate FI. The FCR was calculated by dividing FI by ADG.

Experimental chicks were randomly selected at day 42 (feed was removed 12 hours before sampling) after LBW had been measured, using a precision scale (±0.1 g). A total of 300 (150 males and 150 females; 30 quail randomly selected among closest to average LBWs form each trial group of both genders; six from each replicate group) quail were slaughtered. Slaughter (by decapitation) and carcass butchery were carried out as reported by Genchev & Mihaylov (2008). In the evaluation of slaughter and carcass parameters, a sensitive scale (±0.01 g) was used. The eviscerated carcasses were left to stand at +4 °C for 24 hours and then reweighed to determine cold carcass weight and carcass yield. The cold carcasses were butchered and the weights of drumstick, chest, wing, back, neck and other parts were determined. The carcass parameters were established via the cold carcass weight.

On days 21 and 42, anti-coagulant tubes were used to obtain blood samples from 10 quail (two randomly selected, among the closest to average from each of the replicate groups) in each subgroup of both genders.

Table 1 Ingredient composition and analysed content of nutrients of the diets used in the trial (starter diet, days 1–21; grower diet, days 22–42)

Ingredients (%)	Starter Diet	Grower Diet	Nutritional content, DM basis (%)	Starter Diet	Grower Diet
Yellow corn	47.00	52.30	Dry matter	89.90	89.80
Wheat	7.40	10.50	Metabolic energy		
Vegetable oil	1.50	1.00	kcal/kg	2899	2899
Soybean meal (48% CP)	29.20	24.00	MJ/kg	12.14	12.14
Fish meal (64% CP)	3.50	-	Crude protein	24.00	20.00
Sunflower meal (%32 HP)	9.25	8.90	Crude fat	3.20	2.80
Limestone	0.92	1.25	Crude fibre	4.65	4.54
Vit. min. prem.*	0.25	0.25	Crude ash	5.64	6.06
Salt	0.35	0.35	Calcium	0.80	0.90
DCP	0.45	1.35	P	0.38	0.37
L-Lysine	-	0.05	Na	0.20	0.18
Antioxidant	0.08	-	Cl	0.28	0.26
D-L Methionine	-	0.02	Meth. + Cysteine	0.85	0.71
L-Threonine	0.10	0.03	Lysine	1.30	1.01
			Threonine	1.02	0.76
			Tryptophan	0.31	0.26

*Supplied 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-pantothenate, 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 ester, 120 mg Mn, 100 mg Zn, 90 mg Fe, 16 mg Cu, 1,5 mg I, 0.75 mg Co, 0.30 mg Se

The blood samples were centrifuged at 3000 rpm for 10 minutes and the resulting sera were stored at -20 °C until they were analysed. Serum sample levels of AST, ALP, cholesterol, high-density lipoprotein (HDL), total protein (TP), and ALB were measured in an auto analyser (ADVIA 1800 Chemistry System).

The normality of distribution for all data was tested with the Shapiro-Wilk test at 95% confidence interval. A *P* value of ≤0.05 was interpreted as different. The statistical analysis for normal distribution data of the dietary groups was carried out with the general linear model procedure of SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). The results are expressed as mean ± standard deviation of five replications. Duncan's multiple range test was used for multiple comparisons in important groups. Data points bearing different letters are significantly different *P* ≤0.05. For the distribution of data that was different from normal, Kruskal Wallis H-Test was applied as a nonparametric test and the results were expressed as median, minimum and maximum values. Pairwise comparisons of groups were made when Kruskal Wallis H-Test was significant.

Results and Discussion

Table 2 shows the LBW of quail at various times, according to gender and dietary group. It was determined that the difference between male and female chicks was not significant according to dietary group (*P* >0.05). When the LBW of male quail were evaluated at various periods, it was found that the LBW of those in the trial 4% group was higher than other groups at days 7 (*P* <0.01), 14 (*P* <0.05), and 21 (*P* <0.01). In female quail, there were improved LBW in treatment groups compared with control at all stages (*P* <0.001). In these chicks, the highest LBW at day 21 was higher in the trial 3% group (*P* <0.001). In addition, the yeast autolysate feed groups were similar in terms of LBW on day 42.

Between one and six quail died in each group (Table 2), so mortality was not treatment related during the experimental period. This is consistent with the findings of a previous study of poultry fed with diets supplemented with yeast and yeast products (Yalçın *et al*., 2010).

Table 2 Effects of dietary supplementation of yeast autolysate on live bodyweights of quail at various periods (g)

Periods (days)	Sex	Control (Basal diet)		Trial 1%		Trial 2%		Trial 3%		Trial 4%		P
		N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD	
Hatching	M	100	8.09 ± 0.17	100	8.01 ± 0.21	100	7.90 ± 0.18	100	7.97 ± 0.31	100	7.94 ± 0.23	NS
	F	100	8.07 ± 0.23	100	8.07 ± 0.28	100	8.03 ± 0.18	100	8.05 ± 0.25	100	8.09 ± 0.19	NS
7th day	M	100	17.60^{b} ± 0.37	100	17.47^{b} ± 0.46	100	17.74^{b} ± 0.41	100	18.19^{ab} ± 0.71	99	18.80^{a} ± 0.55	**
	F	99	17.20^{c} ± 0.50	97	17.93^{b} ± 0.62	100	18.12^{ab} ± 0.42	100	18.64^{ab} ± 0.59	100	18.81^{a} ± 0.45	***
14th day	M	98	37.31^{b} ± 0.79	96	37.66^{b} ± 1.00	97	37.36^{b} ± 0.86	100	37.32^{b} ± 1.45	97	39.51^{a} ± 1.15	*
	F	97	35.85^{b} ± 1.04	97	36.65^{b} ± 1.26	98	39.96^{a} ± 0.92	100	40.01^{a} ± 1.25	99	40.89^{a} ± 0.97	***
21st day	M	98	59.93^{b} ± 1.27	96	62.84^{b} ± 1.66	96	63.29^{b} ± 1.45	100	59.07^{b} ± 2.29	97	65.71^{a} ± 1.92	**
	F	95	58.41^{c} ± 1.70	94	63.76^{b} ± 2.19	95	62.21^{b} ± 1.43	98	67.85^{a} ± 2.13	97	67.01^{a} ± 1.59	***
28th day	M	98	93.26 ± 1.97	96	97.26 ± 2.57	96	97.50 ± 2.24	99	95.17 ± 3.69	95	98.26 ± 2.87	NS
	F	95	90.99^{c} ± 2.64	94	95.87^{b} ± 3.29	95	95.20^{b} ± 2.19	98	100.97^{a} ± 3.17	97	101.57^{a} ± 2.41	***
35th day	M	98	131.20 ± 2.78	96	130.98 ± 3.46	96	133.07 ± 3.06	99	131.30 ± 5.08	95	134.83 ± 3.93	NS
	F	95	129.75^{c} ± 3.77	94	145.09^{a} ± 4.98	95	136.19^{b} ± 3.13	98	144.34^{a} ± 4.53	97	143.95^{a} ± 3.42	***
42nd day	M	98	150.58 ± 3.19	95	152.29 ± 4.03	96	152.93 ± 3.51	99	154.37 ± 5.98	95	156.00 ± 4.55	NS
	F	94	167.09^{b} ± 4.85	94	185.65^{a} ± 6.38	95	182.98^{a} ± 4.21	96	184.85^{a} ± 5.81	97	187.93^{a} ± 4.46	***

NS: not significant (P >0.05), *: P <0.05, **: P <0.01, ***: P <0.001, M: male, F: female, SD: standard deviation
[a, b, c]Means in the same row followed by different letters are different according to Duncan's multiple range test (P <0.05)

Table 3 shows the ADGs, FIs, and FCRs of quail at various periods, according to gender and dietary groups. During the starter period, grower period, and overall experiment periods, both male and female quail fed the diets containing different levels of yeast autolysate had significantly higher ADG, FI, and FCR than the control group (P values are given in Table 3), with the exception of ADG for male quail during the overall period. Over the experiment, ADGs for the treatment groups were higher than those of the control group in female quail (P <0.001). In terms of FI and FCR (1–42 days), it was found that trial 2% was lower than all other groups in both genders (P >0.001). In addition, it was found that the trial 2% group showed the best performance of the groups in which yeast autolysate was added to the diet.

The finding that the added yeast autolysate groups performed better than the control group in terms of ADG and FCR is in accordance with the better performance that was observed with the addition of MOS and β-glucans (Mousa *et al*., 2014), and with the addition of MOS in both male and female quail, in terms of ADG and FCR (Maha *et al*., 2013). Yalçın *et al*. (2013) found that the addition of yeast autolysate to broiler rations in days 1–21 and then days 22–42 improved FCR. The performance-enhancing effect of MOS is because of its ability to reduce the proliferation of pathogenic bacteria in the digestive system, as well as maintaining the health of the digestive system, allowing it to work more efficiently, and affording greater nutrient absorption (Haldar *et al*., 2011; 2013; Mousa *et al*., 2014).

In some studies, it was found that the use of yeast and yeast products in poultry had no effect on ADG (Bonos *et al*., 2010a; Aydın & Aydın 2012), FI (Haldar *et al*., 2011; Yalçın *et al*., 2013), and FCR (Aydın & Aydın 2012; Maha *et al*., 2013). The reasons may include the diversity of yeast and yeast products (MOS, yeast extract, yeast autolysate and prebiotics) added to the feed, the rates (0.5, 1.0, 2.0, 3.0, 4.0 g/kg), and percentages (1, 2, 3%) that were used, and the difference in animal species (broiler and quail) used in the studies.

Table 3 Effects of yeast autolysate supplementation on daily live weight gain (g/day/bird), daily food intake (g/day/bird), and feed conversion rate (g/g) of quail at different periods

Factors	Sex	Control	Trial 1%	Trial 2%	Trial 3%	Trial 4%	P
			Starter period (from 1st to 21st day)				
ADG	M	$2.02^{b} \pm 0.04$	$2.16^{a} \pm 0.06$	$2.17^{a} \pm 0.05$	$1.95^{b} \pm 0.07$	$2.23^{a} \pm 0.06$	**
	F	$1.97^{c} \pm 0.06$	$2.18^{b} \pm 0.08$	$2.10^{b} \pm 0.05$	$2.34^{a} \pm 0.07$	$2.29^{a} \pm 0.05$	***
FI	M	$7.91^{b} \pm 0.17$	$7.78^{b} \pm 0.21$	$7.39^{c} \pm 0.17$	$7.16^{c} \pm 0.28$	$8.26^{a} \pm 0.24$	***
	F	$7.96^{ab} \pm 0.23$	$7.68^{b} \pm 0.26$	$7.19^{c} \pm 0.17$	$8.04^{a} \pm 0.25$	$7.99^{ab} \pm 0.19$	***
FCR	M	$3.93^{a} \pm 0.08$	$3.60^{b} \pm 0.10$	$3.41^{c} \pm 0.08$	$3.68^{b} \pm 0.14$	$3.70^{b} \pm 0.11$	***
	F	$4.06^{a} \pm 0.12$	$3.52^{b} \pm 0.12$	$3.43^{b} \pm 0.08$	$3.43^{b} \pm 0.11$	$3.48^{b} \pm 0.08$	***
			Grower period (from 22nd to 42nd day)				
ADG	M	$4.32^{b} \pm 0.09$	$4.26^{b} \pm 0.11$	$4.27^{b} \pm 0.10$	$4.54^{a} \pm 0.17$	$4.30^{b} \pm 0.13$	*
	F	$5.18^{c} \pm 0.15$	$5.80^{a} \pm 0.20$	$5.75^{ab} \pm 0.13$	$5.57^{b} \pm 0.18$	$5.76^{ab} \pm 0.14$	***
FI	M	$18.93^{b} \pm 0.40$	$17.69^{c} \pm 0.47$	$17.19^{c} \pm 0.39$	$19.21^{b} \pm 0.74$	$20.04^{a} \pm 0.58$	***
	F	$21.87^{a} \pm 0.63$	$21.47^{a} \pm 0.74$	$19.69^{b} \pm 0.45$	$21.08^{a} \pm 0.66$	$21.35^{a} \pm 0.51$	***
FCR	M	$4.38^{b} \pm 0.09$	$4.15^{c} \pm 0.11$	$4.03^{d} \pm 0.09$	$4.23^{bc} \pm 0.17$	$4.66^{a} \pm 0.14$	***
	F	$4.23^{a} \pm 0.12$	$3.70^{b} \pm 0.13$	$3.42^{c} \pm 0.08$	$3.78^{b} \pm 0.12$	$3.71^{b} \pm 0.09$	***
			Overall experiment (from 1st to 42nd day)				
ADG	M	3.16 ± 0.07	3.21 ± 0.08	3.22 ± 0.08	3.24 ± 0.12	3.27 ± 0.10	NS
	F	$3.57^{b} \pm 0.10$	$3.99^{a} \pm 0.14$	$3.93^{a} \pm 0.09$	$3.96^{a} \pm 0.12$	$4.03^{a} \pm 0.09$	***
FI	M	$13.42^{b} \pm 0.28$	$12.74^{cd} \pm 0.34$	$12.29^{d} \pm 0.28$	$13.19^{bc} \pm 0.51$	$14.15^{a} \pm 0.41$	***
	F	$14.92^{a} \pm 0.44$	$14.58^{a} \pm 0.50$	$13.44^{b} \pm 0.31$	$14.56^{a} \pm 0.46$	$14.67^{a} \pm 0.35$	***
FCR	M	$4.24^{a} \pm 0.09$	$3.97^{b} \pm 0.11$	$3.82^{c} \pm 0.09$	$4.07^{b} \pm 0.16$	$4.33^{a} \pm 0.13$	***
	F	$4.18^{a} \pm 0.12$	$3.65^{b} \pm 0.12$	$3.42^{c} \pm 0.08$	$3.67^{b} \pm 0.12$	$3.64^{b} \pm 0.09$	***

NS: not significant (P >0.05), *: P <0.05, **: P <0.01, ***: P <0.001, M: male, F: female
[a, b, c, d]Means in the same row followed by different letters are different according to Duncan's multiple range test (P <0.05)
Values represent mean ± standard deviation
LBW: live bodyweight, ADG: average daily live weight gain, FI: feed intake, FCR: feed conversion rate

The effects of dietary yeast autolysate on slaughter, carcass weights, and percentages in quail are given in Tables 4, 5, and 6. Slaughter weight, hot carcass weight, and cold carcass weight of female quail fed the diets containing 1%, 2%, 3%, and 4% yeast autolysate were higher than those of the control group (P <0.05). However, the addition of yeast autolysate was not effective in all groups for male quail (P >0.05).

The finding that the addition of yeast autolysate was higher in carcass weight in female quail is in accordance with the results of the studies conducted by Bonos *et al*. (2010a), Abd-Allah & Andel-Raheem (2012), and Mousa *et al*. (2014), but contrasts with the findings of Bonos *et al*. (2010b), Aydin & Aydin (2012), and Yalçın *et al*. (2013). The observation that the addition of yeast autolysate had no effect on the carcass weight in male quail is in accordance with the results of the study that Özcan *et al*. (2016) conducted on male quail.

The addition of yeast autolysate had no effect on the weights of heart, gizzard, leg, wings, back, and neck (P >0.05) in male and female quail. However, the added yeast autolysate groups were higher than those of the control group in terms of the weights of the liver (P <0.05), breast (P <0.01), and other parts (P <0.05) in female

quail. And it was found that trial 1% was lower than all other groups in terms of the weight of intestines in male quail (P <0.05).

Table 4 The influence of dietary supplementation with yeast autolysate on the weights of slaughter and carcass attributes of quail (g)

Parameters	Sex	N	Control	Trial 1%	Trial 2%	Trial 3%	Trial 4%	P
Slaughter	M	30	150.6 ± 18.2	152.3 ± 14.9	152.9 ± 12.2	154.4 ± 15.2	156.0 ± 11.7	NS
	F	30	167.1^{b} ± 17.4	185.6^{a} ± 14.4	183.0^{a} ± 17.6	184.9^{a} ± 22.4	187.9^{a} ± 20.4	*
Hot carcass$^{\#}$	M	30	112.4 ± 14.6	116.8 ± 7.6	115.7 ± 9.2	114.1 ± 11.7	115.6 ± 9.4	NS
	F	30	119.7^{b} ± 12.2	130.5^{a} ± 11.2	128.8^{a} ± 11.1	127.4^{a} ± 14.0	128.7^{a} ± 11.4	*
Cold carcass$^{\#}$	M	30	109.7 ± 14.1	113.12 ± 7.12	113.4 ± 9.4	111.3 ± 11.2	113.5 ± 9.4	NS
	F	30	115.1^{b} ± 12.6	126.12^{a} ± 11.04	124.7^{a} ± 11.3	123.9^{a} ± 14.8	124.3^{a} ± 11.4	*
Heart	M	30	1.53 ± 0.23	1.45 ± 0.22	1.39 ± 0.14	1.40 ± 0.22	1.64 ± 0.39	NS
	F	30	1.65 ± 0.41	1.79 ± 0.41	1.67 ± 0.23	1.67 ± 0.25	1.67 ± 0.27	NS
Liver	M	30	2.88 ± 0.46	2.95 ± 0.40	2.96 ± 0.50	3.25 ± 0.93	3.04 ± 0.44	NS
	F	30	4.13^{b} ± 0.83	4.98^{a} ± 1.25	4.96^{a} ± 1.17	4.76^{ab} ± 0.93	5.18^{a} ± 1.09	*
Intestines	M	30	6.13^{a} ± 1.16	4.97^{b} ± 1.11	5.89^{a} ± 1.30	6.33^{a} ± 0.96	5.80^{a} ± 1.61	*
	F	30	7.88 ± 1.39	7.36 ± 2.84	7.52 ± 1.43	7.66 ± 1.31	8.36 ± 1.13	NS
Reproductive organs	M	30	2.64^{b} ± 1.20	3.32^{ab} ± 1.36	2.97^{ab} ± 1.24	2.60^{b} ± 1.40	3.72^{a} ± 0.92	*
Gizzard	M	30	3.00 ± 0.52	3.01 ± 0.34	2.81 ± 0.62	2.90 ± 0.44	2.96 ± 0.30	NS
	F	30	3.61 ± 0.51	3.65 ± 0.46	3.97 ± 0.66	3.53 ± 0.60	3.63 ± 0.41	NS
Foot	M	30	3.12^{b} ± 0.32	3.30^{ab} ± 0.36	3.29^{ab} ± 0.30	3.35^{a} ± 0.36	3.47^{a} ± 0.23	*
	F	30	3.52 ± 0.38	3.40 ± 0.86	3.62 ± 0.37	3.26 ± 0.83	3.12 ± 0.32	NS
Abdominal fat	M	30	0.93^{a} ± 0.16	0.65^{ab} ± 0.06	0.58^{b} ± 0.05	0.80^{ab} ± 0.12	0.94^{a} ± 0.06	*
	F	30	1.42^{b} ± 0.12	1.97^{a} ± 0.25	1.41^{b} ± 0.15	0.98^{b} ± 0.17	1.50^{ab} ± 0.17	**
Leg	M	30	26.31 ± 3.81	26.17 ± 1.94	27.11 ± 3.18	26.80 ± 3.00	27.16 ± 2.39	NS
	F	30	27.18 ± 3.43	29.11 ± 3.03	29.56 ± 2.93	28.41 ± 3.84	28.79 ± 3.36	NS
Breast	M	30	40.10 ± 5.96	41.19 ± 3.52	39.48 ± 8.14	40.00 ± 4.05	40.45 ± 3.51	NS
	F	30	41.99^{b} ± 4.67	47.61^{a} ± 5.62	48.60^{a} ± 5.49	45.62^{a} ± 6.29	45.33^{ab} ± 5.25	**
Wing	M	30	9.26 ± 0.76	9.44 ± 0.69	9.52 ± 1.27	9.84 ± 0.87	9.58 ± 0.84	NS
	F	30	10.29 ± 0.90	9.99 ± 1.20	10.19 ± 1.17	9.93 ± 0.92	10.33 ± 1.06	NS
Back	M	30	12.65 ± 2.16	13.17 ± 1.61	13.69 ± 2.38	12.64 ± 2.23	13.20 ± 1.61	NS
	F	30	13.45 ± 2.20	14.14 ± 1.99	12.77 ± 2.30	14.27 ± 1.90	13.99 ± 1.49	NS
Neck	M	30	8.85 ± 1.40	9.75 ± 1.56	10.07 ± 1.21	9.16 ± 2.47	9.84 ± 1.65	NS
	F	30	9.75 ± 1.91	10.83 ± 1.55	9.59 ± 1.94	10.75 ± 2.37	10.83 ± 1.54	NS
Other	M	30	12.57 ± 2.51	13.40 ± 1.82	13.59 ± 2.15	12.90 ± 1.84	13.29 ± 1.98	NS
	F	30	12.47^{b} ± 2.35	14.43^{a} ± 1.65	13.95^{a} ± 2.01	14.97^{a} ± 2.49	15.05^{a} ± 2.62	*

NS: not significant (P >0.05), *: P <0.05, **: P <0.01, ***: P <0.001, M: male, F: female
$^{a, b, c}$Means in the same row followed by different letters are different according to Duncan's multiple range test (P <0.05)
Values represent mean ± standard deviation
$^{\#}$Eviscerated carcass weight with neck weight

With regard to hot and cold carcass yields, the highest yields in male quail were found in the trial 1% and trial 2% groups (P <0.01), and the lowest yield in female quail was observed in the trial 4% group (P <0.05). Bonos *et al*. (2010a), Aydin & Aydin (2012), and Yalçın *et al*. (2013) found that the addition of yeast, yeast products, and MOS did not affect carcass yield. In contrast, Vahdatpour *et al*. (2011) and Mousa *et al*. (2014) found that this addition increased carcass yield. Since female quail have higher carcass weight than male quail, but lower carcass yield, the role of gender in carcass weight and carcass yield is important. These variations can be attributed to their anatomical differences (Bonos *et al*., 2010b).

Table 5 Effects of dietary administration with yeast autolysate on slaughter and carcass percentages of quail (%)

Parameters	Sex	N	Control	Trial 1%	Trial 2%	Trial 3%	Trial 4%	P
Hot carcass yield[1]	M	30	$74.56^{bc} \pm 1.31$	$77.00^{a} \pm 4.07$	$75.68^{ab} \pm 1.35$	$73.91^{c} \pm 1.01$	$74.08^{c} \pm 1.35$	**
	F	30	$71.70^{a} \pm 2.79$	$70.34^{ab} \pm 3.50$	$70.57^{ab} \pm 4.42$	$69.05^{b} \pm 2.79$	$68.69^{b} \pm 3.40$	*
Cold carcass yield[1]	M	30	$72.80^{bc} \pm 1.64$	$74.62^{a} \pm 3.99$	$74.19^{ab} \pm 1.45$	$72.12^{c} \pm 1.33$	$72.74^{bc} \pm 1.40$	**
	F	30	$68.90^{a} \pm 2.34$	$67.95^{ab} \pm 3.02$	$68.26^{ab} \pm 3.55$	$67.09^{ab} \pm 2.62$	$66.33^{b} \pm 3.14$	*
Heart[1]	M	30	1.02 ± 0.11	0.95 ± 0.11	0.91 ± 0.09	0.91 ± 0.12	1.05 ± 0.27	NS
	F	30	0.98 ± 0.20	0.96 ± 0.19	0.91 ± 0.12	0.91 ± 0.17	0.89 ± 0.12	NS
Liver[1]	M	30	1.92 ± 0.30	1.95 ± 0.30	1.93 ± 0.28	2.10 ± 0.49	1.95 ± 0.26	NS
	F	30	2.47 ± 0.42	2.69 ± 0.63	2.69 ± 0.50	2.58 ± 0.42	2.75 ± 0.47	NS
Intestines[1]	M	30	4.07 ± 0.13	3.30 ± 0.18	3.87 ± 0.20	4.11 ± 0.13	3.72 ± 0.22	NS
	F	30	4.72 ± 0.16	3.94 ± 0.32	4.11 ± 0.15	4.19 ± 0.18	4.47 ± 0.13	NS
Reproductive organs[1]	M	30	$1.74^{b} \pm 0.73$	$2.15^{ab} \pm 0.83$	$1.94^{ab} \pm 0.80$	$1.67^{b} \pm 0.87$	$2.39^{a} \pm 0.57$	*
Gizzard[1]	M	30	1.99 ± 0.21	1.99 ± 0.25	1.84 ± 0.40	1.88 ± 0.23	1.91 ± 0.22	NS
	F	30	2.17 ± 0.27	1.98 ± 0.27	2.18 ± 0.38	1.95 ± 0.57	1.95 ± 0.26	NS
Foot[1]	M	30	2.08 ± 0.11	2.18 ± 0.25	2.16 ± 0.17	2.17 ± 0.17	2.23 ± 0.14	NS
	F	30	$2.12^{a} \pm 0.21$	$1.84^{b} \pm 0.46$	$1.99^{ab} \pm 0.24$	$1.79^{b} \pm 0.48$	$1.93^{ab} \pm 0.23$	*
Abdominal fat[1]	M	30	$0.58^{ab} \pm 0.41$	$0.42^{bc} \pm 0.18$	$0.38^{c} \pm 0.14$	$0.51^{abc} \pm 0.32$	$0.61^{a} \pm 0.19$	*
	F	30	$0.84^{ab} \pm 0.27$	$1.05^{a} \pm 0.54$	$0.76^{b} \pm 0.34$	$0.51^{c} \pm 0.38$	$0.79^{b} \pm 0.36$	**
Leg[2]	M	30	24.00 ± 1.93	23.14 ± 0.97	23.93 ± 2.48	24.07 ± 1.17	23.93 ± 0.93	NS
	F	30	23.59 ± 1.10	23.07 ± 0.91	23.72 ± 1.11	22.91 ± 1.30	23.14 ± 1.34	NS
Breast[2]	M	30	36.50 ± 2.08	36.44 ± 2.47	34.70 ± 6.16	35.98 ± 2.09	35.66 ± 1.50	NS
	F	30	$36.53^{b} \pm 2.15$	$37.68^{ab} \pm 1.71$	$38.94^{a} \pm 1.71$	$36.79^{b} \pm 2.08$	$36.49^{b} \pm 2.75$	**
Wing[2]	M	30	8.52 ± 0.91	8.36 ± 0.61	8.40 ± 1.00	8.86 ± 0.57	8.45 ± 0.58	NS
	F	30	8.98 ± 0.66	7.93 ± 0.78	8.19 ± 0.80	8.05 ± 0.59	8.31 ± 0.44	NS
Back[2]	M	30	11.50 ± 0.98	11.65 ± 1.23	12.05 ± 1.80	11.31 ± 1.31	11.64 ± 1.19	NS
	F	30	$11.68^{a} \pm 1.26$	$11.23^{a} \pm 1.42$	$10.23^{b} \pm 1.43$	$11.56^{a} \pm 1.15$	$11.29^{a} \pm 1.08$	*
Neck[2]	M	30	8.05 ± 0.68	8.60 ± 1.13	8.91 ± 1.03	8.21 ± 1.92	8.64 ± 1.00	NS
	F	30	8.43 ± 1.06	8.61 ± 1.09	7.70 ± 1.45	8.63 ± 1.32	8.71 ± 0.98	NS
Other[2]	M	30	11.43 ± 1.49	11.81 ± 1.25	12.00 ± 1.86	11.58 ± 1.09	11.67 ± 1.12	NS
	F	30	$10.79^{b} \pm 1.44$	$11.48^{ab} \pm 1.24$	$11.23^{ab} \pm 1.55$	$12.06^{a} \pm 1.20$	$12.06^{a} \pm 1.39$	*

NS: not significant (P >0.05), *: P <0.05, **: P <0.01, M: male, F: female
[a, b, c] Means in the same row followed by different letters are different according to Duncan's multiple range test (P <0.05)
Values represent mean ± standard dev.; [1]Proportioned to live body weight before slaughter; [2]Proportioned to cold carcass

In the present study, it was determined that heart, liver, intestine, and gizzard percentage were not affected in either male or female quail (*P* >0.05), which was consistent with the results of Aydin & Aydin (2012) and Abd-Allah & Andel-Raheem (2012). Bonos *et al*. (2010a, b) found that the addition of MOS reduced the liver percentage in quail and did not affect the heart percentage. Mousa *et al*. (2014) reported that the addition of MOS and β-glucans reduced the liver and gizzard percentages in quail, but did not affect the heart percentage. Vahdatpour *et al*. (2011) found that the addition of inactive yeast did not affect the intestine percentage in male quail, although it was lower in the gizzard, heart, and liver percentage. Inactive yeast did not affect the heart, gizzard, intestine, and liver percentage in female quail.

Table 6 Effects of dietary supplementation of yeast autolysate on reproductive organ weights (g) and percentages (%) of female quail

Parameters		Control	Trial 1%	Trial 2%	Trial 3%	Trial 4%	P
Weights	N	30	30	30	30	30	
	Median	3.69[b]	9.63[a]	4.10[b]	12.24[a]	14.07[a]	
	Min	1.24	1.17	1.04	1.53	1.79	**
	Max	17.83	24.68	22.99	28.06	26.34	
Percentages[1]	N	30	30	30	30	30	
	Median	2.16[b]	4.82[a]	2.23[b]	6.73[a]	7.31[a]	
	Min	0.72	0.70	0.60	0.95	1.16	*
	Max	9.14	13.15	12.41	12.70	14.39	

**P* <0.05, ***P* <0.01, M: male, F: female, min: minimum, max: maximum
[a, b, c] Medians in the same row followed by different letters are different (*P* <0.05)
[1] Proportioned to live bodyweight before slaughter

The lowest abdominal fat percentage was observed in the trial 2% in male quail (*P* <0.05), and in the trial 3% group in female quail (*P* <0.01). Similar results reported by Mousa *et al*. (2014) determined that the additions of MOS and β-glucans reduced the abdominal fat ratio in quail. It was found that MOS addition had no effect on the abdominal fat ratio in broilers in studies with Bozkurt et al. (2009) and without gender discrimination (Falaki *et al*., 2011).

The addition of yeast autolysate did not affect the size of any part of the carcass in male quail (*P* >0.05). In female quail it was found that the breast percentage was higher in trial 2% than in the control (*P* <0.01), and the back percentage was lowest in the trial 2% group (*P* <0.05). Although Falaki *et al*. (2011) and Moss *et al*. (2014) reported that the addition of MOS and β-glucans was higher in the breast percentage in broilers and quail, respectively, Bonos *et al*. (2010a) and Aydin & Aydin (2012) found that it had no effect. The finding that the addition of yeast autolysate did not affect the leg percentage in the present study is consistent with the results obtained by Bonos *et al*. (2010b), Falaki *et al*. (2011) and Mousa *et al*. (2014).

With regard to reproductive organs, it was found that the difference between the groups was significant in both male and female quail. This was thought to be because the use of yeast autolysate, which contains proteins, MOS, and β-glucan, accelerates the development of testes, the male reproductive organ, and leads to earlier puberty and laying of eggs for females.

Some blood serum parameters are important since they provide information about metabolic disorders and the diagnosis of diseases. Various blood serum parameters are provided in Table 7.

It was found that cholesterol and HDL decreased as increasing amounts of yeast autolysate were added to the food rations (the lowest was in the trial 3% group), and were higher when the ration contained 4% yeast autolysate for both genders at day 21. The trial 4% group had the highest AST (*P* <0.001), ALP (*P* <0.001), TP (*P* >0.05) and ALB (*P* <0.05) on day 42, and the cholesterol level was lower in trial 2% (*P* <0.05) than control in male quail. Mousa *et al*. (2014) found that the addition of MOS and β-glucans had no effect on ALB and AST

levels, but there were lower cholesterol and HDL levels and higher TP levels in mixed gender groups of quail. On the other hand, Yalçın *et al*. (2013) found that the addition of yeast autolysate to food rations did not affect AST, cholesterol, and TP levels in groups of broilers of mixed gender. The yeast autolysate that used as a prebiotic in this study consists of 40% crude protein and 32% MOS and β-glucans. In the current study, high levels of TP and ALB in male quail may be associated with positive effects on protein metabolism and high protein content of yeast autolysate. MOS addition to poultry rations has been reported to improve protein digestibility (Yang *et al*., 2007) by increasing villus height in small intestines (Spring, 1996).

Table 7 Effects of yeast autolysate supplementation on some quail blood serum parameters on days 21 and 42

Parameters	Days	Sex	N	Control	Trial 1%	Trial 2%	Trial 3%	Trial 4%	P
AST (U/L)	21	M	30	188.17 ± 15.43	155.67 ± 8.94	143.50 ± 17.50	136.17 ± 10.54	130.83 ± 16.71	NS
		F	30	152.83 ± 14.23	129.00 ± 12.22	149.00 ± 25.36	150.50 ± 15.37	100.00 ± 10.63	NS
	42	M	30	170.83^{b} ± 9.86	171.67^{b} ± 7.57	140.83^{b} ± 7.18	173.17^{b} ± 12.28	262.00^{a} ± 16.42	***
		F	30	201.33 ± 15.79	191.00 ± 13.72	145.33 ± 20.82	151.83 ± 12.47	182.17 ± 15.19	NS
ALP (U/L)	21	M	30	1667.67 ± 170.00	1586.17 ± 118.43	1475.00 ± 145.86	1419.50 ± 80.00	1319.17 ± 144.40	NS
		F	30	1595.33 ± 166.37	1416.17 ± 130.61	1631.00 ± 259.15	1488.00±162.36	972.67 ± 69.01	NS
	42	M	30	414.50^{b} ± 21.08	430.83^{b} ± 35.06	425.00^{b} ± 14.27	498.67^{b} ± 63.93	670.00^{a} ± 49.34	***
		F	30	546.00 ± 49.20	532.00 ± 64.30	430.17 ± 48.59	517.00 ± 65.42	716.50 ± 110.47	NS
Cholesterol (mg/dL)	21	M	30	146.17^{a} ±1 2.04	130.67^{ab} ± 13.22	109.83^{bc} ± 11.35	88.33^{c} ± 2.94	106.50^{bc} ± 11.31	**
		F	30	111.67 ± 11.31	104.00 ± 8.20	92.67 ± 9.88	78.33 ± 8.56	97.17 ± 13.88	NS
	42	M	30	142.00^{a} ± 9.96	122.50^{ab} ± 6.89	108.33^{b} ± 3.04	139.00^{a} ± 11.84	149.33^{a} ± 9.23	*
		F	30	160.67 ± 25.74	183.17 ± 28.65	120.17 ± 15.28	112.00 ± 7.43	138.33 ± 16.32	NS
HDL (mg/dL)	21	M	30	98.22^{a} ± 9.03	83.30^{a} ± 6.88	77.42 ± 8.12^{ab}	60.05^{b} ± 5.72	62.22^{b} ± 2.62	*
		F	30	73.23 ± 6.04	68.80 ± 7.12	59.93 ± 3.86	51.40 ± 7.73	61.10 ± 6.23	NS
	42	M	30	99.43 ± 7.15	81.95 ± 5.87	75.27 ± 1.26	93.97 ± 8.75	94.62 ± 5.73	NS
		F	30	55.53^{ab} ± 3.98	46.80^{bc} ± 3.12	46.20 ± 3.76^{bc}	41.95^{c} ± 1.42	62.80^{a} ± 3.05	**
TP (g/dL)	21	M	30	2.07 ± 0.18	1.87 ± 0.20	1.75 ± 0.23	1.52 ± 0.14	1.32 ± 0.13	NS
		F	30	1.77 ± 0.19	1.65 ± 0.19	1.63 ± 0.17	1.62 ± 0.14	1.18 ± 0.13	NS
	42	M	30	1.50 ± 0.19	1.40 ± 0.13	1.60 ± 0.07	1.65 ± 0.23	2.17 ± 0.20	NS
		F	30	2.93 ± 0.19	2.60 ± 0.22	2.55 ± 0.56	2.17 ± 0.18	2.82 ± 0.35	NS
ALB (g/dL)	21	M	30	0.98 ± 0.11	0.90 ± 0.11	0.85 ± 0.13	0.72 ± 0.09	0.60 ± 0.08	NS
		F	30	0.87 ± 0.10	0.77 ± 0.11	0.80 ± 0.09	0.80 ± 0.08	0.50 ± 0.07	NS
	42	M	30	0.62^{b} ± 0.09	0.60^{b} ± 0.08	0.65^{b} ± 0.04	0.72^{b} ± 0.11	0.98^{a} ± 0.09	*
		F	30	1.35 ± 0.10	1.15 ± 0.11	1.13 ± 0.27	0.97 ± 0.09	1.30 ± 0.17	NS

NS: not significant (P >0.05), *: P <0.05, **: P <0.01, ***: P <0.001
[a, b, c] Means in the same row followed by different letters are different according to Duncan's test (P <0.05)
Values represent mean ± standard deviation
AST: aspartate aminotransferase, ALP: alkaline phosphatase, HDL: high-density lipoprotein, TP: total protein, ALB: albumin

Conclusions

The present study demonstrated that the addition of 2% yeast autolysate to diet could be used as a performance enhancer for quail during the first 42 days of life. This research found that supplementation of yeast autolysate in male and female quail resulted in higher growth performance compared with the control group for

the duration of the study. Abdominal fat percentage (except trial 4%) was lower, while the carcass yield increased in trial 1% and 2% male quail. Abdominal fat percentage (except trial 1%) was higher, while the carcass yield was reduced in trial 4% female quail. In general, good performance and reduced abdominal fat percentage and cholesterol levels were observed in the group on dietary supplemented with 2% yeast autolysate.

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Authors' Contributions

MB was in charge of organizing and supervising the course of the project and the article. MB and Kİ took responsibility for the logical interpretation and presentation of the results. MB wrote the manuscript.

Conflict of Interest Declaration

The authors declare no conflict of interest.

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