Effect of dietary raw and fermented sour cherry kernel (*Prunus cerasus* L.) on growth performance, carcass traits, and meat quality in broiler chickens

Emrah Gungor[1] and Guray Erener

Department of Animal Science, Faculty of Agriculture, Ondokuz Mayis University, 55200 Samsun, Turkey

ABSTRACT Sour cherry kernels are waste products of the fruit juice industry. Solid-state fermentation has great potential for recycling the agro-industrial residues. In the present study, the effect of raw sour cherry kernel (RC) and fermented sour cherry kernel (FC) by *Aspergillus niger* on growth performance, carcass traits and meat quality in broiler chickens was investigated. A total of 343 one-day-old male broilers (Ross 308) were randomly allocated to 7 treatments with 7 replicates for each treatment and 7 birds in each replicate. The chicks were fed on a basal diet (control) and basal diet supplemented with RC or FC at the 1, 2, and 4% level. Dietary RC improved ($P < 0.001$) the feed conversion ratio (FCR) at the 1% inclusion level although chicks fed 2 and 4% RC had lower ($P < 0.01$) body weight (BW), body weight gain (BWG), and feed intake (FI) from day 1 to 42, compared with that of the birds in the control group. Dietary FC with 1% inclusion level increased ($P \leq 0.05$) BWG from day 22 to 42 and also enhanced ($P < 0.001$) the FCR from day 1 to 42. However, 4% dietary FC had an adverse effect ($P < 0.01$) on BW, BWG, FI, and the FCR, compared with the control group. The bursa of Fabricius weight was raised ($P < 0.01$) as the supplemental FC level increased. Dietary RC and FC elevated gut weight ($P < 0.01$) and length ($P \leq 0.05$). Broilers fed on 2% FC had a higher ($P \leq 0.05$) ash level and a lower ($P \leq 0.05$) b* value in thigh meat, compared with the 2% RC group. The results indicate that FC can be used in broiler nutrition up to 2% level although RC can be added to broiler diets up to 1% level without a detrimental effect on growth performance. Dietary inclusion of 1% RC or FC can be recommended due to the positive effects on broiler chickens.

Key words: sour cherry kernel, *Prunus cerasus* L., growth performance, carcass traits, broiler chicken

2020 Poultry Science 99:301–309
http://dx.doi.org/10.3382/ps/pez490

INTRODUCTION

The rapid increase in the world population is forcing scientists to find alternative feed sources for cereal grains, which are the principal components of human diets. Several researchers have focused on the utilization of agricultural residues produced at a rate of billions of tonnes every year (Xie et al., 2016). Sour cherry (*Prunus cerasus* L.) is a stone fruit from the *Rosaceae* family, which has reached 1.2 million tonnes of annual production worldwide (FAOSTAT, 2017). High amounts of kernels are discarded during the processing of sour cherry. But these kernels have the potential to improve growth performance and meat quality in poultry due to their phenolic components and beta carotene content (Kim et al., 2005; Yilmaz and Gokmen, 2013). However, the inclusion of raw sour cherry kernel (**RC**) in poultry diets can be limited due to its low methionine content and high cellulose content, as well as possessing antinutritional factors, such as cyanogenic glycosides, which have a harmful effect on the growth performance of broiler chickens (Arbouche et al., 2012; Altop, 2019).

In recent years, solid-state fermentation has been an effective tool for recycling agro-industrial residues in useful animal feeds. Solid-state fermentation has improved the nutritional composition of shea nut (Dei et al., 2008), cottonseed meal (Jazi et al., 2017), pine needle (Wu et al., 2015), olive leaves (Altop et al., 2018), and sweet cherry (*Prunus avium* L.) kernel (Altop, 2019). *Aspergillus niger* can produce various enzymes, such as protease, amylase, lipase, cellulase, and tannase (Couri et al., 2000; Wu et al., 2015), and also decrease antinutritional components in *Ginkgo biloba* leaves (Zhang et al., 2012), cottonseed meal (Jazi et al., 2017), and olive leaves (Xie et al., 2016) with solid-state fermentation. Similarly, our previous study demonstrated that *A. niger* enhanced the nutritional composition of sour cherry kernel in solid-state fermentation (Gungor et al., 2017). Altop (2019) showed that fermented sweet cherry kernel can be used at the 1% level in broiler diets without any detrimental effect on performance parameters. However, there is a lack of information about the effects of either raw or fermented sour cherry kernel (**FC**) on growth performance, carcass

Received May 9, 2019.
Accepted August 7, 2019.
[1]Corresponding author: emrah.gungor@omu.edu.tr

Table 1. Changes in nutritional composition of sour cherry kernel before and after fermentation.

Item (% dry matter)	Before fermentation	After fermentation	Change
Metabolic energy (kcal/kg)	3220.6	3280.6	60.0
Crude protein	29.6	34.9	5.3
Ether extract	16.6	24.6	8.0
Ash	3.10	5.1	2.0
Nitrogen-free extract	23.2	15.1	–8.1
Crude fiber	27.5	20.3	–7.2

traits, and meat quality in broiler chickens. Therefore, the aim of this study was to investigate the effects of RC and FC on growth performance, carcass traits, and meat quality in broilers.

MATERIALS AND METHODS

Culturing of A. niger

The *A. niger* strain (ATCC 200345) used in this study was obtained from American Type Culture Collection (ATCC). It was cultured in potato dextrose agar at 24°C for 7 D, according to the agar plate technique. *Aspergillus niger* spores were harvested by turning the plate upside down and gently hitting the top. Spore counting was conducted according to the Fuchs-Rosenthal technique; approximately 10^4 spores were counted (Wu et al., 2015).

Preparation of FC Sample

Solid-state fermentation was conducted according to Cao et al. (2012) with some modifications. Raw sour cherry kernel was obtained from a juice factory (Dimes, Tokat, Turkey) and milled to 2 mm and stored at −20°C until fermentation. It was supplemented with nutritional salt consisting of glucose, urea, $(NH_4)_2SO_4$, peptone, KH_2PO_4, and $MgSO_4.7H_2O$ (40, 20, 60, 10, 40, and 10 g in 1 L distilled water for each 1 kg sample, respectively) to encourage microorganism growth after autoclave sterilization. Solid-state fermentation was conducted by incubating the sample at 30°C for 7 D. At the end of fermentation, the sample was dried on a polyethylene sheet in a room at 30 to 40°C until 90% dry matter (**DM**) was obtained, which was milled to a size of 2 mm. The changes in nutritional composition of sour cherry kernel before and after fermentation are given in Table 1.

Animals, Diets, and Experimental Design

A total of 343 one-day-old Ross 308 male broiler chicks (~38.9 g) were purchased from a local commercial hatchery (Ross Breeders Anadolu, Ankara, Turkey). Birds were randomly allocated to 7 treatment groups with 7 replicates for each treatment and 7 birds in each replicate in a completely randomized design. The birds were housed in wire-floored pens in an environmentally controlled room at a maintained temperature of 32°C for the first 3 D, then the environmental temperature was gradually reduced by 1°C every 2 D until it reached a final temperature of 20°C. The light regimen was continuous light for the first 3 D after hatching, followed by a schedule of 23 h of light and 1 h of dark throughout the experiment. Meanwhile, all broiler chicks had ad libitum access to feed and fresh water. All birds were vaccinated against Newcastle disease on days 0 and 9, against Gumboro on day 15, and against infectious bursal disease on days 0, 9, and 19.

During the entire rearing period, all broiler chicks were randomly allocated to 7 dietary treatments. Birds were fed a maize-soybean meal-based basal mash diet (control) and the basal diet supplemented by RC at 1% (**RC1**), 2% (**RC2**), 4% (**RC4**) and FC at 1% (**FC1**), 2% (**FC2**), and 4% (**FC4**). The composition of the diets and nutrient levels for the starter (day 1 to 11), grower 1 (day 12 to 21), grower 2 (day 22 to 35), and finisher phases (day 36 to 42) were formulated to meet the NRC's (1994) nutrient requirements, as shown in Tables 2 and 3. The experimental design and procedures were approved by the Ethical Committee of Ondokuz Mayis University (with protocol number: 2017/09).

Experimental Procedures

Bird's weight and feed consumption were recorded weekly in grams on a pen basis. The performance variables measured in this study include body weight (**BW**), body weight gain (**BWG**), feed intake (**FI**), and feed conversion ratio (**FCR**). Mortality was recorded daily in order to calculate mortality rate and to adjust FCR. At the end of the experiment (42 D of age), one bird from each pen was starved overnight, but with access to fresh water, and sacrificed by decapitation. Carcass traits, the weight of the heart, liver, spleen, bursa of Fabricius, gizzard, pancreas, gut, and abdominal fat were measured on a digital scale with an accuracy of 0.1 g. The relative organ weights were calculated as a percentage in the live weight of birds and expressed as g per 100 g BW. The gut length was determined by a tape measure and expressed as cm per 100 g BW.

The color of breast and thigh muscle was measured at 45 min postmortem. The measurements were taken from 3 locations for each sample and average values were given. Lightness (L*), redness (a*), and yellowness (b*) values were determined from one bird from each pen using a Chroma Meter (CR300, Konica Minolta, Osaka, Japan).

The pH values of breast and thigh muscles were measured from one bird from each replicate using a portable pH meter (Mi151, Martini Instruments, Hungary), equipped with an inserted glass electrode (FC 200B, Hanna Instruments, Padova, Italy), at 45 min postmortem, according to Cao et al. (2012). The pH probe was inserted at an angle of 45° into the pectoralis major and rinsed with deionized water after each

Table 2. Ingredients and nutrient composition of experimental diets in starter (day 1 to 11) and grower 1 (day 12 to 21) periods.

	Starter (day 1 to 11)[1]							Grower 1 (day 12 to 21)[1]						
Ingredients (g/kg)	CON	RC1	RC2	RC4	FC1	FC2	FC4	CON	RC1	RC2	RC4	FC1	FC2	FC4
Corn	434.8	430.4	425.9	417.1	430.4	425.9	417.1	438.5	434.1	429.6	420.7	434.1	429.6	420.7
Soybean meal (46%)	255.2	252.6	250.0	244.8	252.6	250.0	244.8	155.0	153.4	151.9	148.7	153.4	151.9	148.7
Full-fat soybean (35%)	140.0	138.6	137.1	134.3	138.6	137.1	134.3	200.0	198.0	195.9	191.9	198.0	195.9	191.9
Corn gluten	100.0	99.0	98.0	95.9	99.0	98.0	95.9	100.0	99.0	98.0	95.9	99.0	98.0	95.9
Sunflower meal (36%)	–	–	–	–	–	–	–	35.0	34.6	34.3	33.6	34.6	34.3	33.6
Meat and bone meal (35%)	50.0	49.5	49.0	48.0	49.5	49.0	48.0	58.0	57.4	56.8	55.6	57.4	56.8	55.6
Raw sour cherry kernel	–	10.0	20.0	40.0	–	–	–	–	10.0	20.0	40.0	–	–	–
Fermented sour cherry kernel	–	–	–	–	10.0	20.0	40.0	–	–	–	–	10.0	20.0	40.0
Dicalcium phosphate (18%)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	–	–	–	–	–	–	–
Marble dust (38%)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Salt	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
DL Methionine	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.1	2.1	2.1	2.1	2.1	2.1	2.1
L Lysine HCl	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Threonine	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vitamin and mineral premix[2]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin D3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sodium sulfate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Anticoccidial	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Toxin binder	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Nutrient composition														
Metabolizable energy (kcal/kg)	3,000	3,002	3,004	3,009	3,003	3,006	3,011	3,050	3,052	3,053	3,057	3,052	3,055	3,059
Crude protein	230	231	231	233	231	232	235	220	221	222	223	221	223	225
Ether extract	55.8	56.9	58.0	60.2	57.7	59.6	63.4	68.1	69.1	70.1	72.0	69.9	71.7	75.2
Crude fiber	33.9	36.3	38.7	43.6	35.6	37.3	40.6	40.3	42.7	45.0	49.7	41.9	43.5	46.8
Ash	53.0	52.5	52.0	51.0	52.5	52.0	51.1	48.5	48.0	47.6	46.7	48.1	47.6	46.8
Lysine	14.0	14.0	14.0	14.0	14.0	14.0	14.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Methionine	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Methionine and cystine	10.5	10.5	10.5	10.5	10.5	10.5	10.5	9.9	9.9	9.9	9.9	9.9	9.9	9.9
Threonine	9.8	9.8	9.8	9.8	9.8	9.8	9.8	8.9	8.9	8.9	8.9	8.9	8.9	8.9
Tryptophan	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Calcium	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Total P	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Available P	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Na	1.8	1.8	1.8	1.8	1.8	1.8	1.8	2.1	2.1	2.1	2.1	2.1	2.1	2.1

[1]CON: basal diet; RC1, RC2, and RC4: basal diet with 1, 2, 4% raw sour cherry kernel, respectively; FC1, FC2, FC4: basal diet with 1, 2, 4% fermented sour cherry kernel, respectively.

[2]Premix provided per kilogram of diet: 12,000 IU retinol; 2,400 IU cholecalciferol; 40 mg α-tocopherol; 4 mg menadione; 3 mg thiamine; 6 mg riboflavin; 25 mg nicotinic acid; 10 mg pantothenic acid; 5 mg pyridoxine; 0.03 mg cyanocobalamin; 0.05 mg biotin; 1 mg folic acid; 80 mg Mn; 60 mg Zn; 60 mg Fe; 5 mg Cu; 0.2 mg Co; 1 mg I; 0.15 mg Se, 200 mg choline chloride.

measurement. Each sample was measured 3 times, and the average value was taken as the final result.

The carcasses were chilled at 4°C for 24 h and then weighed; drip loss was also calculated as a ratio of chilled carcass to hot carcass. The carcasses were divided into breast, thigh, wing and back, with each weighed to calculate their yield as a percentage of BW (%). A sample was taken from 3 birds of each treatment for the proximate analysis (DM, crude protein [**CP**], ether extract [**EE**], and ash). The percentages of DM and ash were determined in triplicate, according to the Association of Official Analytical Chemists (AOAC, 2000) procedure. CP was determined using a standard Kjeldahl method (AOAC, 2000). EE was determined with an oil extractor (XT15, ANKOM Technology) using petroleum ether.

The water-holding capacity (**WHC**) of meat samples was measured using a press technique, as described by Altop (2019) from 3 birds of each treatment. One gram of the sample was placed on a filter paper (Whatman No. 1), set between 2 plexiglass plates, and pressed for 20 min using a 1-kg weight. The outlines of the expressed juice and the pressed meat film were traced, and the 2 areas were measured using a Placom Digital Planimeter (KP-90, Sokkisha Planimeter, Kanagawa, Japan). The WHC was calculated as a percentage of the meat film area in relation to the total juice area.

Statistical Analysis

The effects of dietary treatment were statistically analyzed by 1-way ANOVA using the SPSS statistical software (Version 21.0, SPSS, Chicago, IL). The statistical differences between treatment groups were determined by a Duncan test. Mortality rates were analyzed using the chi-square test. The orthogonal polynomial contrast test was performed to determine the linear and quadratic effects of increasing the inclusion level of RC or FC in the diet. All data are presented as means and pooled SEM. Significance (P value) was evaluated at the 0.05 level. For performance data, pen

Table 3. Ingredients and nutrient composition of experimental diets in grower 2 (day 22 to 35) and finisher (day 36 to 42) periods.

	Grower 2 (day 22 to 35)[1]							Finisher (day 36 to 42)[1]						
Ingredients (g/kg)	CON	RC1	RC2	RC4	FC1	FC2	FC4	CON	RC1	RC2	RC4	FC1	FC2	FC4
Corn	493.5	488.5	483.5	473.5	488.5	483.5	473.5	533.6	528.2	522.8	512.1	528.2	522.8	512.1
Soybean meal (46%)	101.1	100.1	99.1	97.0	100.1	99.1	97.0	53.0	52.5	51.9	50.9	52.5	51.9	50.9
Full-fat soybean (35%)	200.0	198.0	195.9	191.9	198.0	195.9	191.9	210.0	207.9	205.8	201.5	207.9	205.8	201.5
Corn gluten	100.0	99.0	98.0	95.9	99.0	98.0	95.9	100.0	99.0	98.0	96.0	99.0	98.0	96.0
Sunflower meal (36%)	35.0	34.6	34.3	33.6	34.6	34.3	33.6	35.0	34.6	34.3	33.6	34.6	34.3	33.6
Meat and bone meal (35%)	58.0	57.4	56.8	55.7	57.4	56.8	55.7	60.0	59.4	58.8	57.6	59.4	58.8	57.6
Raw sour cherry kernel	–	10.0	20.0	40.0	–	–	–	–	10.0	20.0	40.0	–	–	–
Fermented sour cherry kernel	–	–	–	–	10.0	20.0	40.0	–	–	–	–	10.0	20.0	40.0
Marble dust (38%)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	–	–	–	–	–	–	–
Salt	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.3	1.3	1.3	1.3	1.3	1.3	1.3
DL Methionine	2.1	2.1	2.1	2.1	2.1	2.1	2.1	1.9	1.9	1.9	1.9	1.9	1.9	1.9
L Lysine HCl	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Threonine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vitamin and mineral premix[2]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Sodium sulfate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Anticoccidial	0.6	0.6	0.6	0.6	0.6	0.6	0.6	–	–	–	–	–	–	–
Nutrient composition														
Metabolizable energy (kcal/kg)	3,100	3,101	3,102	3,105	3,102	3,104	3,107	3,150	3,151	3,151	3,153	3,151	3,153	3,155
Crude protein	200	201	202	204	201	203	206	185	186	187	189	187	188	192
Ether extract	69.2	70.2	71.1	73.1	71.0	72.7	76.3	72.0	72.9	73.9	75.8	73.7	75.5	79.0
Crude fiber	39.4	41.8	44.1	48.8	41.0	42.7	45.9	39.1	41.5	43.8	48.5	40.7	42.4	45.6
Ash	44.5	44.1	43.7	42.8	44.1	43.7	42.9	39.7	39.3	39.0	38.2	39.4	39.0	38.3
Lysine	11.6	11.6	11.6	11.6	11.6	11.6	11.6	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Methionine	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Methionine and cystine	9.2	9.2	9.2	9.2	9.2	9.2	9.2	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Threonine	8.1	8.1	8.1	8.1	8.1	8.1	8.1	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Tryptophan	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Calcium	8.5	8.5	8.5	8.5	8.5	8.5	8.5	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Total P	6.9	6.9	6.9	6.9	6.9	6.9	6.9	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Available P	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Na	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.7	1.7	1.7	1.7	1.7	1.7	1.7

[1]CON = basal diet, RC1, RC2, and RC4 = basal diet containing 1, 2, 4% raw sour cherry kernel, respectively, FC1, FC2, FC4 = basal diet containing 1, 2, 4% fermented sour cherry kernel, respectively.

[2]Premix provided per kilogram of diet: 12,000 IU retinol; 2,400 IU cholecalciferol; 40 mg α-tocopherol; 4 mg menadione; 3 mg thiamine; 6 mg riboflavin; 25 mg nicotinic acid; 10 mg pantothenic acid; 5 mg pyridoxine; 0.03 mg cyanocobalamin; 0.05 mg biotin; 1 mg folic acid; 80 mg Mn; 60 mg Zn; 60 mg Fe; 5 mg Cu; 0.2 mg Co; 1 mg I; 0.15 mg Se, 200 mg choline chloride.

means served as the experimental unit for statistical analysis. For data on carcass traits and meat quality, individual birds were considered as the experimental units.

RESULTS

Performance

The average mortality rate was 0.6%, and there were no significant differences among the treatment groups.

Broilers fed on RC2, RC4, and FC4 had lower ($P <$ 0.001) BW compared with the control group on the 21st and 42nd days of age (Table 4). Similarly, the BWG of birds in the RC2, RC4, and FC4 groups was also lower ($P < 0.001$) than that of birds in the control group in the period from day 1 to 21 and the overall period from day 1 to 42. Birds fed on FC1 had the highest ($P \leq 0.05$) BWG in the treatment groups during the period from day 22 to 42 and a quadratic ($P = 0.004$) effect was observed as the supplemental FC level was increased.

The FI of the birds from the RC2 and RC4 groups was lower than that of the birds in the control group from day 22 to 42 ($P \leq 0.05$) and in the overall period from day 1 to 42 ($P < 0.01$), whereas there was no difference among the treatment groups from day 1 to 21 with regard to FI. Chickens from the FC4 group exerted a decreased ($P < 0.01$) FI, compared with the control group from day 1 to 42.

Birds fed on RC2 and FC4 had increased ($P < 0.001$) FCR in the period from day 1 to 21, compared with the control group. In addition, the FCR of birds fed on FC4 was also impaired ($P < 0.001$) during the overall period from day 1 to 42, compared with the control group. However, the FCR of birds in the RC1 group was enhanced ($P < 0.001$) during the overall period from day 1 to 42. Furthermore, FC1 improved the FCR, not only in the period from day 22 to 42 ($P \leq 0.05$) but also in the overall period ($P < 0.001$).

There was a linear ($P < 0.001$) decrease in BW, BWG, and FI for the overall period, which increased the level of RC in the diet. The dietary inclusion of FC decreased BW and BWG linearly ($P < 0.001$ and $P < 0.001$, respectively) and quadratically ($P = 0.003$ and $P = 0.003$, respectively) and also increased FCR linearly ($P = 0.002$) and quadratically ($P < 0.001$)

Table 4. Effects of dietary RC and FC on performance parameters of broiler chickens.

Item (g)	Days	Dietary treatment[1]							SEM	P	Effect of RC[2]		Effect of FC[3]	
		CON	RC1	RC2	RC4	FC1	FC2	FC4			L	Q	L	Q
BW	0	38.83	39.00	38.98	38.98	38.94	38.87	38.84	0.068	NS	NS	NS	NS	NS
	21	813[a]	794[a,b]	736[c]	767[b]	799[a]	787[a,b]	721[c]	5.7	***	***	*	***	**
	42	2,796[a,b]	2,833[a]	2,698[c,d]	2,712[c,d]	2,835[a]	2,754[b,c]	2,661[d]	11.8	***	***	NS	***	**
BWG	1 to 21	775[a]	755[a,b]	697[c]	728[b]	760[a]	748[a,b]	682[c]	5.7	***	***	*	***	*
	22 to 42	1,948[b]	1,989[a,b]	1,963[b]	1,945[b]	2,036[a]	1,968[b]	1,940[b]	8.1	*	NS	NS	NS	**
	1 to 42	2,757[a,b]	2,794[a]	2,659[c,d]	2,673[c,d]	2,796[a]	2,715[b,c]	2,622[d]	11.8	***	***	NS	***	**
FI	1 to 21	1,057	1,028	1,007	1,019	1,043	1,019	1,005	5.7	NS	*	NS	**	NS
	22 to 42	3,451[a]	3,441[a]	3,381[b]	3,386[b]	3,430[a,b]	3,431[a,b]	3,422[a,b]	6.7	*	***	NS	NS	NS
	1 to 42	4,526[a]	4,469[a–c]	4,393[c]	4,402[c]	4,482[a,b]	4,450[a–c]	4,428[b,c]	10.7	**	***	NS	**	NS
FCR, g:g	1 to 21	1.37[c]	1.36[c]	1.45[a,b]	1.40[b,c]	1.37[c]	1.36[c]	1.47[a]	0.009	***	*	NS	***	**
	22 to 42	1.77[a]	1.73[a,b]	1.72[a,b]	1.74[a,b]	1.69[b]	1.74[a,b]	1.76[a]	0.008	*	NS	NS	NS	**
	1 to 42	1.64[b]	1.60[c]	1.65[b]	1.65[b]	1.60[c]	1.64[b]	1.69[a]	0.006	***	NS	NS	**	***

[a–d]Means within the same row that have no common superscript are significantly different ($P \leq 0.05$).
n = 7.
BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio, RC = raw sour cherry kernel, FC = fermented sour cherry kernel.
L = linear, Q = quadratic, * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$.
[1]CON = basal diet, RC1, RC2, and RC4 = basal diet containing 1, 2, 4% raw sour cherry kernel, respectively, FC1, FC2, FC4 = basal diet containing 1, 2, 4% fermented sour cherry kernel, respectively.
[2,3]Orthogonal polynomials were used to determine linear and quadratic effect of raw and fermented sour cherry kernel.

throughout the overall period. Moreover, FI was linearly ($P = 0.005$) decreased by FC inclusion.

Carcass Traits

The effect of dietary inclusion of RC and FC on carcass traits is presented in Table 5. Dietary treatments had no effect on the carcass yield, drip loss, abdominal fat, and the yield of breast, thigh, wing, and back. Chickens fed on FC2 and FC4 diets had a higher ($P < 0.01$) bursa of Fabricius weight than the control and RC groups. The bursa of Fabricius weight showed a linear ($P < 0.001$) increase with the inclusion level of FC in the diet. Increasing levels of RC and FC in the diet linearly raised ($P < 0.001$) digestive system weight ($P = 0.003$ and $P < 0.001$, respectively) and length ($P = 0.012$ and $P < 0.001$, respectively). There was no difference among the treatment groups with regard to heart, liver, spleen, gizzard, and pancreas weight.

Meat Quality

The dietary inclusion of RC and FC did not alter pH, WHC, DM, CP, EE, L*, and a* values in either breast or thigh meat (Table 6). Birds fed on FC2 had a higher ($P \leq 0.05$) ash level and a lower ($P \leq 0.05$) b* value in thigh meat, compared with the RC2 group, although there was no difference among the treatment groups in breast meat with regard to ash and the b* value. The ash content of thigh meat was quadratically influenced ($P = 0.043$), thereby increasing the level of RC in the diet, but was also affected linearly ($P = 0.039$), as the FC level increased in the diet.

DISCUSSION

Altop (2019) reported that dietary 1% raw sweet cherry kernel raised BWG in broiler chickens from day 1 to 21 in contrast to this study, but did not change BWG from day 1 to 41 in parallel to the results of the present study. Moreover, the FI of the broilers fed on 1% RC was not altered, compared with that of the birds in the control group in this study, although Altop (2019) indicated that 1% raw sweet cherry kernel increased FI in broiler chickens**.** The FCR was worsened by 1% supplemental raw sweet cherry kernel in broilers (Altop, 2019), although dietary 1% RC supplementation ameliorated the FCR in the overall period, compared with the control group in this study. Kim et al. (2005) showed that phenolic compounds of RC are higher than those in sweet cherry kernel. Phenolic compounds have positive effects on BW and FCR in broiler chickens (Starčević et al., 2015). It is suggested that the improvement in FCR may be due to phenolic compounds in RC. However, BW was diminished as the supplemental RC level increased in the present study. Arbouche et al. (2012) showed that the dietary addition of apricot kernel at 6% and higher levels had negative effects on growth performance in broilers, which is

Table 5. Effects of dietary RC and FC on carcass traits of broiler chickens.

	Dietary treatment[1]									Effect of RC[2]		Effect of FC[3]	
Item (%)	CON	RC1	RC2	RC4	FC1	FC2	FC4	SEM	P	L	Q	L	Q
Carcass yield	77.3	78.1	76.1	77.8	76.6	76.5	74.9	0.36	NS	NS	NS	NS	NS
Drip loss	3.0	2.8	2.7	2.6	2.8	2.7	2.2	0.22	NS	NS	NS	NS	NS
Breast yield	25.9	25.7	24.7	25.7	25.5	24.3	24.0	0.25	NS	NS	NS	*	NS
Thigh yield	23.7	24.0	24.3	24.5	23.8	23.8	24.1	0.15	NS	NS	NS	NS	NS
Wing yield	7.3	7.4	6.9	7.5	7.1	7.2	7.2	0.08	NS	NS	NS	NS	NS
Back yield	13.3	13.8	12.8	13.1	13.3	14.2	12.8	0.14	NS	NS	NS	NS	NS
Abdominal fat	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.02	NS	NS	NS	NS	NS
Gut weight	5.7^{c}	$6.4^{a,b}$	$6.3^{a–c}$	$6.6^{a,b}$	$6.1^{b,c}$	$6.1^{b,c}$	6.8^{a}	0.08	**	**	NS	***	NS
Gut length	7.5^{c}	$7.8^{b,c}$	$7.7^{b,c}$	$8.2^{a,b}$	$7.7^{b,c}$	$7.9^{b,c}$	8.6^{a}	0.08	**	*	NS	***	NS
Heart	0.42	0.45	0.45	0.46	0.41	0.44	0.44	0.008	NS	NS	NS	NS	NS
Liver	1.68	1.78	1.70	1.73	1.68	1.73	1.70	0.022	NS	NS	NS	NS	NS
Spleen	0.08	0.08	0.08	0.10	0.09	0.08	0.08	0.003	NS	NS	NS	NS	NS
Bursa of Fabricius	0.18^{b}	0.19^{b}	0.19^{b}	0.20^{b}	$0.21^{a,b}$	0.24^{a}	0.24^{a}	0.006	**	NS	NS	***	NS
Gizzard	1.08	1.01	1.18	1.09	1.08	1.18	1.17	0.024	NS	NS	NS	NS	NS
Pancreas	0.23	0.19	0.22	0.24	0.21	0.22	0.23	0.006	NS	NS	NS	NS	NS

[a–d]Means within the same row that have no common superscript are significantly different ($P \leq 0.05$).
n = 7.
RC = raw sour cherry kernel, FC = fermented sour cherry kernel.
L = linear, Q = quadratic, * = $P \leq 0.05$, ** = $P < 0.01$, *** = $P < 0.001$.
[1]CON = basal diet, RC1, RC2, and RC4 = basal diet containing 1, 2, 4% raw sour cherry kernel, respectively, FC1, FC2, FC4 = basal diet containing 1, 2, 4% fermented sour cherry kernel, respectively.
[2,3]Orthogonal polynomials were used to determine linear and quadratic effect of raw and fermented sour cherry kernel.

Table 6. Effects of dietary RC and FC on meat quality of broiler chickens.

	Dietary treatment[1]									Effect of RC[2]		Effect of FC[3]	
Item (%)	CON	RC1	RC2	RC4	FC1	FC2	FC4	SEM	P	L	Q	L	Q
Breast muscle													
pH	5.81	6.02	5.99	5.91	5.89	5.78	5.88	0.050	NS	NS	NS	NS	NS
WHC	19.90	20.27	19.78	20.51	19.17	17.26	18.68	0.484	NS	NS	NS	NS	NS
DM, %	26.08	25.79	25.61	26.83	26.97	26.66	26.35	0.196	NS	NS	NS	NS	NS
CP, %	23.26	22.79	22.77	24.21	23.95	23.57	23.01	0.213	NS	NS	NS	NS	NS
EE, %	1.48	1.65	1.40	1.13	1.58	1.75	1.82	0.106	NS	NS	NS	NS	NS
Ash, %	1.34	1.36	1.43	1.49	1.43	1.34	1.52	0.035	NS	NS	NS	NS	NS
L*	58.69	58.69	59.97	59.41	59.05	59.35	59.45	0.290	NS	NS	NS	NS	NS
a*	1.19	1.16	0.68	0.69	1.03	1.23	1.08	0.095	NS	NS	NS	NS	NS
b*	5.40	5.55	5.47	5.30	5.94	5.52	5.67	0.131	NS	NS	NS	NS	NS
Tight muscle													
pH	6.28	6.33	6.47	6.41	6.33	6.36	6.25	0.038	NS	NS	NS	NS	NS
WHC	19.29	19.84	19.35	18.68	18.26	18.11	19.47	0.316	NS	NS	NS	NS	NS
DM, %	23.89	22.77	23.52	24.01	24.15	24.38	24.17	0.204	NS	NS	NS	NS	NS
CP, %	19.69	19.02	19.51	19.96	20.00	20.24	19.95	0.178	NS	NS	NS	NS	NS
EE, %	2.86	2.63	2.81	2.74	2.83	2.59	2.71	0.054	NS	NS	NS	NS	NS
Ash, %	$1.34^{a,b}$	1.12^{b}	1.20^{b}	$1.32^{a,b}$	$1.32^{a,b}$	1.55^{a}	1.52^{a}	0.043	*	NS	*	*	NS
L*	58.37	58.61	59.70	58.66	59.32	57.41	59.07	0.272	NS	NS	NS	NS	NS
a*	3.13	3.29	3.68	3.54	3.28	2.98	3.01	0.093	NS	NS	NS	NS	NS
b*	$5.97^{a–c}$	$6.34^{a–c}$	7.29^{a}	$6.96^{a,b}$	$5.64^{b,c}$	5.42^{c}	$6.21^{a–c}$	0.178	*	NS	NS	NS	NS

[a–c]Means within the same row that have no common superscript are significantly different ($P \leq 0.05$).
n = 3 (WHC, DM, CP, EE, ash) and 7 (pH, L*, a*, b*).
WHC = water-holding capacity, CP = crude protein, EE = ether extract, L* = Lightness, a* = redness, b* = yellowness, RC = raw sour cherry kernel, FC = fermented sour cherry kernel.
L = linear, Q = quadratic, * = $P \leq 0.05$.
[1]CON = basal diet, RC1, RC2, and RC4 = basal diet containing 1, 2, 4% raw sour cherry kernel, respectively, FC1, FC2, FC4 = basal diet containing 1, 2, 4% fermented sour cherry kernel, respectively.
[2,3]Orthogonal polynomials were used to determine linear and quadratic effect of raw and fermented sour cherry kernel.

supposedly due to hydrocyanic acid (**HCN**) content. Similarly, RC contains cyanogenic glycosides (such as amygdalin and prunasin) turn into HCN by the intestinal microbiome and have toxic effects on poultry (Nout et al., 1995; Senica et al., 2016). The adverse effects on the growth performance by the dietary 2 and 4% RC may be due to cyanogenic glycosides in RC. Palm kernel meal has been reported to deteriorate the growth performance of broilers in different studies (Ezieshi and Olomu, 2008; Abdollahi et al., 2016; Navidshad et al., 2016). Likewise, Nagalakshmi (1999) indicated the negative effects on the BW of broilers due to dietary neem (*Azadirachta indica*) kernel meal. Date kernel impaired the performance parameters in broiler chickens (Masoudi et al., 2011), even though Hussein and Alhadrami (2003) reported no changes in growth performance following the inclusion of date kernel in broiler diets. Mango kernel also worsened the performance of broilers by dietary supplementation (Diarra and Usman, 2008), whereas Kumar and Singh (2010) found no change in growth performance among birds receiving either a basal diet or a mango kernel supplemental diet.

Altop (2019) noted that dietary 1% fermented sweet cherry kernel enhanced BWG in the period from day 1 to 21, although dietary 1% FC inclusion increased BWG from day 22 to 42 in this study. Besides, no change in BWG in overall period by dietary 1% fermented sweet cherry kernel was reported by Altop (2019) similar to the result of the present study. Inclusion of 1% FC in broiler diets improved the FCR from day 22 to 42 and in the overall period in the present study, even though no change in the FCR in the case of dietary fermented sweet cherry kernel was reported by Altop (2019). Zhang et al. (2012) and Cao et al. (2012) showed that fermented *G. biloba* leaves ameliorated the FCR in the period from day 22 to 42 and day 1 to 42. Furthermore, Mathivanan et al. (2006) indicated that the BW of the chickens receiving diets supplemented fermented soybean meal was higher than that of the control group. However, the dietary addition of fermented pine needle to broiler diets had no effect on growth performance (Wu et al., 2015). Although there was no change in the FI of birds fed on 1% FC, compared with the control group in the present study, Altop (2019) reported an elevated FI on account of dietary 1% sweet cherry kernel.

Incremental levels of dietary RC impaired the performance parameters of broilers in this study. The negative effects of feed sources on the growth performance of birds can be eliminated by reducing antinutritional factors and disrupting the nutrient utilization of animals by solid-state fermentation (Jazi et al., 2017). Diarra and Usman (2008) reported that dietary raw mango kernel deteriorated the growth performance of broiler chickens although no detrimental effect was observed by dietary fermented mango kernel whose tannin content had been lowered by fermentation. Similarly, the depressed growth performance in broilers was reported by dietary cottonseed meal though dietary inclusion of fermented cottonseed meal did not impair the broiler performance, which was attributed to reducing the gossypol content through fermentation (Jazi et al., 2017). In the present study, although dietary 2% RC reduced BW in broilers, 2% FC inclusion in diets had no detrimental effect on the performance parameters. This may be due to the possible reduction of cyanogenic glycosides in RC by the fermentation process.

Although improvements in the growth of broiler chickens were observed following dietary FC addition (1%), a higher level of FC addition (4%) deteriorated growth performance. This may be attributed to the level of cyanogenic glycosides in FC, which is enough to impair growth performance in the case of 4% dietary inclusion, even if it may be reduced after solid-state fermentation. Apata (2011) indicated that, although *Terminalia catappa* improved growth performance in broilers by diminishing its antinutritional factors, such as tannin and oxalic acid, through fermentation, higher levels of dietary inclusion had negative effects on growth performance, in parallel with the results of the present study. Similarly, chickens receiving supplemented diets with fermented *G. biloba* leaves had a better FCR than birds in the control group, even though higher inclusion levels worsened the FCR in broilers (Niu et al., 2017). Cao et al. (2012) reported an improved FCR with the inclusion of fermented *G. biloba* leaves in broiler diets, but noted no change in FCR with higher levels of fermented leaves.

Immune organ (thymus, spleen, and the bursa of Fabricius) weights are indicators of the immune status in chickens, and are therefore commonly used to evaluate the immunity of chickens (Heckert et al., 2002). The bursa of Fabricius has been suggested as the primary site of immunoglobulin synthesis (Ao et al., 2011). The bursa of Fabricius weight increased in enhanced immune systems (Li et al., 2009) but decreased when immunity was suppressed (Chen et al., 2014). In this study, the bursa of Fabricius was increased linearly with incremental levels of FC in the diet. *Aspergillus niger* had a probiotic effect on broiler chickens when supplementing diets either as spores (Mountzouris et al., 2007) or fermented products (Zhao et al., 2013). An increase in the bursa of Fabricius weight may be attributed to this probiotic effect. Similarly, Li et al. (2009) showed that a probiotic mix including *Lactobacillus* and *Bacillus cereus* raised the weight of the thymus, spleen, and bursa of Fabricius and also increased the antibody titer against Newcastle disease in broilers. Moreover, Ao et al. (2011) reported that fermented red ginseng extract elevated the spleen and bursa of Fabricius weight and also raised the lymphocyte level in broilers. Fermented rapeseed meal did not alter the spleen and bursa of Fabricius weight although the liver weight of birds was increased by its inclusion. However, Altop (2019) noted that the bursa of Fabricius weight was diminished by dietary fermented sweet cherry kernel, although no changes occurred in the spleen weight of broilers. Increase in the bursa of Fabricius weight may indicate that dietary FC is able to improve the immunity of broiler chickens. However, the obtained results should be confirmed by further detailed studies.

Gut relative weight and length provide an insight into the development of the digestive system of chickens (Niu et al., 2018). In the present study, the dietary inclusion of RC and FC linearly increased the relative gut weight and length in broilers. Rahimi et al. (2011) showed that blends of herbal extracts containing phenolic compounds could improve the relative weight of the intestine in broiler chickens. Phenolic compounds in the cherry kernel may cause a rise in gut relative weight and length in the present study. Similarly, fermented *G. biloba* leaves raised the duodenum weight of broilers, compared with the control group (Niu et al., 2018). However, Altop (2019) reported no change in gut weight and length with the supplementation in broiler diets of either raw or fermented sweet cherry kernel. This discrepancy may have been due to the fact that sweet cherry kernel contains fewer phenolic compounds than RC (Kim et al., 2005). This result in the current study suggests that dietary RC or FC supplementation stimulated the development of the digestive system in broilers, but this must be confirmed by further studies.

Ozturk et al. (2012) stated that the ash content of broiler meat was raised by the dietary inclusion of humic substances, which have the effect of improving mineral availability in broiler chickens. Fermentation could improve the mineral content and mineral availability of substrates (Lawal et al., 2010). The increase in the ash content of thigh meat may be due to raising the mineral content or improving the mineral absorption in RC by solid-state fermentation or both.

RC contains high amounts of beta carotene (Yilmaz and Gokmen, 2013). Nevertheless, the b* value of meat samples was not altered by dietary RC. Similar results were reported by Altop (2019), who found no change in the b* value of broiler breast and thigh meat following the inclusion of sweet cherry kernel. However, the thigh meat b* value in the case of birds fed on RC2 was higher than that of the chickens fed on FC2 in this study. Beta carotene may be deteriorated by the autoclaving process before fermentation or consumed by *A. niger* during fermentation or both. However, Altop (2019) indicated that fermented sweet cherry kernel elevated the b* value of breast meat in broilers. Microorganisms can have a different effect on different substrates. Aguilar et al. (2008) showed that the same *A. niger* strain increased the total sugar content in creosote bush leaves, but diminished in pomegranate peels. Neither raw or fermented *G. biloba* leaves nor rapeseed meal had an effect on the color parameters of breast and thigh meat (Cao et al., 2012; Ashayerizadeh et al., 2018). The discrepancy between the studies may be attributed to a different effect of the microorganism on different substrates.

In conclusion, the results of the present study indicated that RC and FC could be a potential feed additive that improves the growth performance in broiler chickens. In addition, RC was converted by the fermentation process to a feedstuff that can be supplemented to broiler diets up to 2% level without any adverse effect on growth performance although RC can be used only up to 1% level in broiler diets. Based on the obtained results, the inclusion of RC at 1% and FC at 1 and 2% can be recommended.

ACKNOWLEDGMENTS

The authors would like to thank Ondokuz Mayis University, Turkey (project number: PYO.ZRT.1904.17.016) for its financial support. The authors would also like to thank Dr Aydin Altop for critically editing the paper.

REFERENCES

Abdollahi, M., B. Hosking, D. Ning, and V. Ravindran. 2016. Influence of palm kernel meal inclusion and exogenous enzyme supplementation on growth performance, energy utilization, and nutrient digestibility in young broilers. Asian-Australas. J. Anim. Sci. 29:539.

Aguilar, C. N., A. Aguilera-Carbo, A. Robledo, J. Ventura, R. Belmares, D. Martinez, R. Rodríguez-Herrera, and J. Contreras. 2008. Production of antioxidant nutraceuticals by solid-state cultures of pomegranate (*Punica granatum*) peel and creosote bush (*Larrea tridentata*) leaves. Food Technol. Biotechnol. 46:218–222.

Altop, A. 2019. The effects of diets supplemented with fermented or non-fermented cherry kernels (*Prunus avium* L.) on growth performance, ileal histology, caecum microflora, and some meat quality parameters in broiler chickens. Eur. Poult. Sci. 83:1–15.

Altop, A., I. Coskun, G. Filik, A. Kucukgul, Y. G. Bekiroglu, H. Cayan, E. Gungor, A. Sahin, and G. Erener. 2018. Amino acid, mineral, condensed tannin, and other chemical contents of olive leaves (*Olea europaea* L.) processed via solid-state fermentation using selected *Aspergillus niger* strains. Cienc Investig. Agr. 45:220–230.

Ao, X., T. Zhou, H. Kim, S. Hong, and I. Kim. 2011. Influence of fermented red ginseng extract on broilers and laying hens. Asian-Australas. J. Anim. Sci. 24:993–1000.

AOAC. 2000. Official Methods of Analysis of AOAC International: 17th ed. AOAC International, USA.

Apata, D. F. 2011. Effect of *Terminalia catappa* fruit meal fermented by *Aspergillus niger* as replacement of maize on growth performance, nutrient digestibility, and serum biochemical profile of broiler chickens. Biotechnol. Res. Int. 2011:1–6.

Arbouche, R., F. Arbouche, H. Arbouche, and Y. Arbouche. 2012. Effects of the incorporation of the apricot kernel meal into broiler diets on growth performance. Rev. Med. Vet. 163:475.

Ashayerizadeh, A., B. Dastar, M. S. Shargh, A. S. Mahoonak, and S. Zerehdaran. 2018. Effects of feeding fermented rapeseed meal on growth performance, gastrointestinal microflora population, blood metabolites, meat quality, and lipid metabolism in broiler chickens. Livest. Sci. 216:183–190.

Cao, F., X. Zhang, W. Yu, L. Zhao, and T. Wang. 2012. Effect of feeding fermented *Ginkgo biloba* leaves on growth performance, meat quality, and lipid metabolism in broilers. Poult. Sci. 91:1210–1221.

Chen, K., J. Fang, X. Peng, H. Cui, J. Chen, F. Wang, Z. Chen, Z. Zuo, J. Deng, and W. Lai. 2014. Effect of selenium supplementation on aflatoxin B1-induced histopathological lesions and apoptosis in bursa of Fabricius in broilers. Food Chem. Toxicol. 74:91–97.

Couri, S., S. da Costa Terzi, G. A. S. Pinto, S. P. Freitas, and A. C. A. da Costa. 2000. Hydrolytic enzyme production in solid-state fermentation by *Aspergillus niger* 3T5B8. Process Biochem. 36:255–261.

Dei, H., S. Rose, A. Mackenzie, and R. Amarowicz. 2008. Growth performance of broiler chickens fed diets containing shea nut (*Vitellaria paradoxa*, Gaertn.) meal fermented with *Aspergillus niger*. Poult. Sci. 87:1773–1778.

Diarra, S., and B. Usman. 2008. Growth performance and some blood variables of broiler chickens fed raw or boiled mango kernel meal. Int. J. Poult. Sci. 7:315–318.

Ezieshi, E. V., and J. M. Olomu. 2008. Nutritional evaluation of palm kernel meal types: 2. Effects on live performance and nutrient retention in broiler chicken diets. Afr. J. Biotechnol. 7:1171–1175.

FAOSTAT. 2017. Food and Agriculture Organization of the United Nations.

Gungor, E., A. Altop, E. Ozturk, and G. Erener. 2017. Nutritional Changes of Sour Cherry (Prunus cerasus) Kernel Subjected to Aspergillus niger Solid-State Fermentation. Pages 99–103. JOTAF The Special Issue of 2nd International Balkan Agriculture Congress.

Heckert, R., I. Estevez, E. Russek-Cohen, and R. Pettit-Riley. 2002. Effects of density and perch availability on the immune status of broilers. Poult. Sci. 81:451–457.

Hussein, A., and G. Alhadrami. 2003. Effect of enzyme supplementation and diets containing date pits on growth and feed utilization of broiler chicks. Agric. Marine Sci. 8:67–71.

Jazi, V., F. Boldaji, B. Dastar, S. Hashemi, and A. Ashayerizadeh. 2017. Effects of fermented cottonseed meal on the growth performance, gastrointestinal microflora population and small intestinal morphology in broiler chickens. Br. Poult. Sci. 58:402–408.

Kim, D.-O., H. J. Heo, Y. J. Kim, H. S. Yang, and C. Y. Lee. 2005. Sweet and sour cherry phenolics and their protective effects on neuronal cells. J. Agric. Food Chem. 53:9921–9927.

Kumar, D., and P. Singh. 2010. Effects of feeding mango seed kernel on performance, carcass characteristics and cost of feeding in broiler starter. Indian J. Poult. Sci. 45:46–49.

Lawal, T., E. Iyayi, B. Adeniyi, and O. Adaramoye. 2010. Biodegradation of palm kernel cake with multienzyme complexes from fungi and its feeding value for broilers. Int. J. Poult. Sci. 9:695–701.

Li, S., X. Zhao, and J. Wang. 2009. Synergy of *Astragalus* polysaccharides and probiotics (*Lactobacillus* and *Bacillus cereus*) on immunity and intestinal microbiota in chicks. Poult. Sci. 88:519–525.

Masoudi, A., M. Chaji, M. Bojarpour, and K. Mirzadeh. 2011. Effects of different levels of date pits on performance, carcass characteristics and blood parameters of broiler chickens. J. Appl. Anim. Res. 39:399–405.

Mathivanan, R., P. Selvaraj, and K. Nanjappan. 2006. Feeding of fermented soybean meal on broiler performance. Int. J. Poult. Sci. 5:868–872.

Mountzouris, K., P. Tsirtsikos, E. Kalamara, S. Nitsch, G. Schatzmayr, and K. Fegeros. 2007. Evaluation of the efficacy of a probiotic containing *Lactobacillus*, *Bifidobacterium*, *Enterococcus*, and *Pediococcus* strains in promoting broiler performance and modulating cecal microflora composition and metabolic activities. Poult. Sci. 86:309–317.

Nagalakshmi, D. 1999. Performance of broiler chicks fed on diets containing urea ammoniated neem (*Azadirachta indica*) kernel cake. Br. Poult. Sci. 40:77–83.

Navidshad, B., J. Liang, M. Jahromi, A. Akhlaghi, and N. Abdullah. 2016. Effects of enzymatic treatment and shell content of palm kernel expeller meal on performance, nutrient digestibility, and ileal bacterial population in broiler chickens. J. Appl. Poult. Res. 25:474–482.

Niu, Y., X. Wan, X. Zhang, L. Zhao, J. He, J. Zhang, L. Zhang, and T. Wang. 2017. Effect of supplemental fermented *Ginkgo biloba* leaves at different levels on growth performance, meat quality, and antioxidant status of breast and thigh muscles in broiler chickens. Poult. Sci. 96:869–877.

Niu, Y., J. Zhang, X. Wan, Q. Huang, J. He, X. Zhang, L. Zhao, L. Zhang, and T. Wang. 2018. Effect of fermented *Ginkgo biloba* leaves on nutrient utilisation, intestinal digestive function and antioxidant capacity in broilers. Br. Poult. Sci. 60:47–55.

Nout, M., G. Tuncel, and L. Brimer. 1995. Microbial degradation of amygdalin of bitter apricot seeds (*Prunus armeniaca*). Int. J. Food Microbiol. 24:407–412.

NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington, DC.

Ozturk, E., N. Ocak, A. Turan, G. Erener, A. Altop, and S. Cankaya. 2012. Performance, carcass, gastrointestinal tract and meat quality traits, and selected blood parameters of broilers fed diets supplemented with humic substances. J. Sci. Food Agric. 92:59–65.

Rahimi, S., Z. Z. Teymouri, T. M. Karimi, R. Omidbaigi, and H. Rokni. 2011. Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. J. Agric. Sci. Technol. 13:527–539.

Senica, M., F. Stampar, R. Veberic, and M. Mikulic-Petkovsek. 2016. Transition of phenolics and cyanogenic glycosides from apricot and cherry fruit kernels into liqueur. Food Chem. 203:483–490.

Starčević, K., L. Krstulović, D. Brozić, M. Maurić, Z. Stojević, Ž. Mikulec, M. Bajić, and T. Mašek. 2015. Production performance, meat composition and oxidative susceptibility in broiler chicken fed with different phenolic compounds. J. Sci. Food Agric. 95:1172–1178.

Wu, Q., Z. Wang, G. Wang, Y. Li, and Y. Qi. 2015. Effects of feed supplemented with fermented pine needles (*Pinus ponderosa*) on growth performance and antioxidant status in broilers. Poult. Sci. 94:1138–1144.

Xie, P., L. Huang, C. Zhang, and Y.-l. Zhang. 2016. Nutrient assessment of olive leaf residues processed by solid-state fermentation as an innovative feedstuff additive. J. Appl. Microbiol. 121: 28–40.

Yilmaz, C., and V. Gokmen. 2013. Compositional characteristics of sour cherry kernel and its oil as influenced by different extraction and roasting conditions. Ind. Crops Prod. 49:130–135.

Zhang, X., F. Cao, Z. Sun, W. Yu, L. Zhao, G. Wang, and T. Wang. 2012. Effect of feeding *Aspergillus niger*-fermented *Ginkgo biloba*-leaves on growth, small intestinal structure and function of broiler chicks. Livest. Sci. 147:170–180.

Zhao, L., X. Zhang, F. Cao, D. Sun, T. Wang, and G. Wang. 2013. Effect of dietary supplementation with fermented *Ginkgo*-leaves on performance, egg quality, lipid metabolism and egg-yolk fatty acids composition in laying hens. Livest. Sci. 155:77–85.