The Effects of Ozonated, Chlorinated, Celestite Stone-Treated, Natural Spring and Pine Resin-Treated Waters on Performance, Oxidative Stress and Carcass Parameters in Japanese Quail [*]

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Abstract:This study was conducted to assess the effects of 5 types of water: Ozonated, Chlorinated, Celestite Stone-treated, Natural Spring Waters and PinResin-treated water on performance, oxidative stress and carcass parameters in Japanese quail. A total of 150, 3-day old mixed female-male quails were used into 5 groups of 30 birds for each water group; each group was divided into 3 replicate sub groups of 10 birds. The experiment was continued for 7 weeks and quail were fed one experimental diet, and the different water sources were given ad libitum during in the trial. Statistical differences among water sources were observed on pH and Electrical Conductivity and content of Ca, Mg, Cl and Total Bacteria. Live weight, daily live weight gain, water and feed intake were the highest in the drinkers of Natural Spring Water, while the lowest for drinkers of Resin-treated Water ($p<0.001$). The lowest level of serum malondialdehyde of was observed in drinkers of Natural Spring Water (1.54 µM/l), and the highest malondialdehyde level in drinkers of Resin-treated Water (4.27 µM/l; $P<0.001$). The sources of water of trial were determined to have noe ffects on slaughter weight, carcass weight and carcass yield ($p>0.05$). As a result, the amount of total dissolved solids of water were the positive effect on live weight, feed consumption, water intake, feed conversion ratio and oxidative stress biomarkers.

Key Words: Celestite stone-treated water, chlorinated water, ozonated water, resin-treated water, water types.

1. Introduction

Water is a vital for the life. The water content of poultry is 55-77% of total body weight although it varies according to species, age and sex; intracellular fluid, contained within cells, accounts for approximately 2/3 of body water and extracellular fluid accounts for 1/3 of body water (1). Water consumption of poultry is 83% (70-97%) provided by directly from the drinking water, and the balance obtained by oxidative metabolism and water consumed in feeds. Water intake is equal to the amount of water lost in feces, urine and breathing (2, 3). Lott et al. (4) reported a correlation of 98% between water consumption and feed consumption. Although water quality of poultry or quail has been researched or reviewed in Turkey (2, 3,5) and the world (6,7,8), and we could not find a study on poultry or quail on the effect of the sources of water similar to those used in our experiment.

2. Materials and methods

Bird Management and Diet: In the study, a total of 150 Japanese quail (*Coturnix coturnix japonica*) were used as experimental animals. Day-old chicks were supplied from a special quail

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farmer in Elazig and placed on experiment from the age of 3 days. This study was started after being approved by Bingol University Animal Experiments Local Ethic Committee (Date: 11.07.2014, Decision No: 2014-03), and carried out at Department of Zootechnic Poultry Breeding Unit at Bingol University. Mixed female-male quail were randomly assigned to 5 groups of 30, and divided into 3 replicate subgroups of 10 birds each. The experiment was run for 7 weeks. Ten chicks were housed in plastic cages of width 34 cm, height 62.5 cm and depth 43 cm with a cleanable base and 5 liter water reservoirs. During the experiment a single diet (Crude Protein, CP 26.14% and Metabolic Energy, ME 3069 kcal/kg) was fed ad libitum to nutrient requirements of quail according to National Research Council (9), (Table 1). Five different waters were given ad libitum for the quail. Sources of waters used in the experiment are given in Table 2. In the study, water intake was calculated weekly by dividing water consumption by number of animals and days. Animals were exposed to light for 24 hours/day during the experiment.

Table 1. Composition of experimental diet

Ingredients	%	Analyzed	%
Corn	50	Dry Matter	89.58
Soybean meal, 48% CP	40	Ash	7.03
Canola Oil	3.0	Crude Protein	26.14
Di Calcium Phosphate	2.25	Crude Cellulose	4.05
Limestone, 38% Ca	3.9	Ether Exract	6.41
Vitamin Premix[1]	0.15	NFE[3]	45.95
Trace Element Premix[2]	0.1	AME, kcal/kg[4]	3095
Ethoxyquin	0.1		
DL-Methionine	0.2		
L-Lysine HCL	0.05		
Salt	0.25		

1: DSM Rovimix 124® per kg: 6500 000 IU Vitamin A, 1500 000 IU Vitamin D3, 25 000 mg Vitamin E, 2500 mg Vitamin K3, 1500 mg Vitamin B1, 3000 mg Vitamin B2, 2500 mg Vitamin B6, 15 mg Vitamin B12, 25000 mg Vitamin C, 5000 mg Calcium D-Pantothenate, 15000 mg Niacin, 500 mg Folic acid, 38 mg Biotin, 250 mg Apo carotenoic acid ester, 62 500 mg Endox D Dry.

2: DSM Remineral S® in each kg: 80000 mg Mn, 60000 mg Fe, 60000 mg Z, 5000 mg Cu, 200 mg Co, 1000 mg I, 150 mg Se, 300000 mg choline chloride.

3: NFE, Nitrogen Free Extract, =% DM- (Crude Protein,% + Crude Cellulose,% + Crude Fat,% + Ash,%).

4: AME, Apparent Metabolic Energy, kcal / kg = 37 x Crude Protein, + 81 x Crude Fat, +35 x NFE, %, (10).

Analyses of Waters, Feed, Bloods and Carcass: Waters were analyzed for pH, Na, K, Cl, Ca, Mg, Electrical Conductivity (EC), total bacteria and fecal bacteria (E. coli) according to Nollet and Gelder (11) in the Soil Department Laboratory and Central Laboratory of Bingol University. EC is also a Total Dissolved Solids (TDS) indicator in water (8,12). Samples of feeds of the experiment were analyzed according to AOAC (13) for dry matter by oven-drying and for ash (Nuve Laboratory Equipment, Istanbul, TR), ether extract (VelpScientifica, Milan, IT) and crude protein (Dumatherm, DE) in Central of University of Bingol Laboratory. Metabolic energy of diets was calculated according to Pauzenga (10). Feed conversion rate (FCR) were determined by daily feed intake/average daily gain (ADG). At the end of the experiment, 4 male and 4 female quails were selected at random from each group and venous bloods were taken into 10 ml tubes with EDTA. Supernants obtained by centrifugation at 3000 rpm for 10 min. were stored at -80 °C until analysis. The oxidative stress biomarkers of the serums were measured in a private laboratory (Oksante Lab., Istanbul) via a cold chain. Serum malondialdehyde (MDA), Superoxide Dismutase (SOD) and Catalase (CAT) enzyme activities were determined according to Buege and Aust (14), Ewing and Jenaro (15) and Goth (16). At 52 days of age of quail or on slaughter day, weights of the organs of the digestive tract except the liver and kidney were separated from those bodies of 5 male and 5 female animals from each group and “hot carcass” weights determined; hot carcass weights were divided by the slaughter weight and “carcass yield” calculated according to Koncaet al. (17).

Table 2. Characteristics of sources of water in the experiment

Sources of Water	Characteristics
Ozonated Water	Commercial ozonated bottled water produced in Solhan District of Bingol was used.
Chlorinated Water	Water of city network in Bingol was used.
Celestite Stone-treated Water	During the trial, 200 g of celestite stone was placed in each reservoir, and 4.5 liters of city water was added. Celestite, strontium sulfate ($SrSO_4$) is considered a stone that reduces stress by the people in Turkey.
Natural Spring Water	Natural spring water flowing from Karliova Fountain near Bingol Central Women's and Children's Hospital was used.
Resin-treated Water	During the trial, 100 g of resin pine wood pieces was placed in each reservoir, and 4.5 liters of city water was added.

Statistical Analysis: A one-way ANOVA analysis was used to assess the significance of the differences between the mean values of the water groups and significant differences of means were determined by Duncan Test of SPSS (1993).

3. Results and Discussion

Table 3. Results of analysis of some parameters of water sources in the experiment

Parameters	Sources of Waters					Water Standards, (1, 4, 7)	p
	Ozonated Water	Chlorinated Water	Celestite Stone-treated Water	Natural Spring Water	Resin-treated Water		
pH	7.00 ^{b}	6.89^{bc}	6.94 ^{b}	7.49 ^{a}	6.30 ^{c}	6.5-9.5	0.018
Ca, ppm	7.47 ^{c}	10.77^{bc}	11.93 ^{b}	11.90 ^{b}	13.13 ^{a}	5-50	0.029
Mg, ppm	18 ^{c}	20^{bc}	22 ^{b}	24 ^{a}	23 ^{a}	10-50	0.035
Na, ppm	2.30	2.27	2.47	3.00	2.30	20-175	0.27
K, ppm	1.70	2.20	2.90	1.97	2.87	12	0.12
Cl, ppm	0.10 ^{b}	0.34 ^{a}	0.20 ^{ab}	0.05 ^{c}	0.26 ^{a}	5	0.005
Electrical Conductivity mikroS/cm	61.17 ^{d}	89.33^{c}	171.33 ^{b}	212.00 ^{a}	110.07^{c}	2500	0.001
Total	286 ^{c}	370 ^{b}	391 ^{b}	566 ^{a}	253 ^{c}	1000	0.038

Bacteria, CFU/ml							
E. coli, CFU/ml	0	0	0	0	0	0	-

[a, b, c, d]: The significant differences between the averages are shown by different letters on the same line.

The reason for the high pH of Natural Spring Water is that high values of Mg, Na, Ca and K or increasing Total Dissolved Solid (TDS) are found in this water. The lowest pH value was found in Resin-treated Water, which was produced by passing water through resins of pine pieces, resulting in acidification of the water. There were no statistically significant differences in Na and K concentrations of the waters ($p>0.05$) and E coli undetectable in all waters. Ca and Mg concentrations are excessive in the Resin-treated water because of retention of cations in the acidic medium (18). The results of all water analysis showed that the waters in the experiment are appropriate according to standards of poultry water (2,12,19).Increasing live weight and ADG of the Natural Spring Water group may be caused by high of concentrations of Mg, Na, Ca and K or increasing of TDS in the water. Live weight and ADG of the Resin-treated Water group of quail were significantly lower than other groups. We think that the reasons for this decrease, stemmed from acidification of the water, decreased feed intake, the watery feces and excessive water intake. Eleroglu et al. (3) reported that the hardness, pH and dissolved oxygen of drinking water had positive effects on live weight and ADG. Marks (6) reported that live weight and ADG of quail depend on the protein content in diet and 20% and 28% of protein of diets resulted in, respectively, live weights of 30.1 and 41.5 g at day 14. Kilany and Mahmoud (20) determined that a diet with 0.5% of Turmeric (Curcuma longa L.) was between 6.06-6.43 g/day on ADG for 7 weeks. Kaplan et al. (21) reported that 1% $NaHCO_3$ in diet gave ADG between 2.70-4.73 g for mixed-sex quail in 7 weeks under temperature stress. Decreased feed consumption and FCR of Resin-treated Water group appears to be caused by acidification of the water and excessive water consumption. The Ozonated, Chlorinated andCelestite Stone-treated waters were similar to each other in their effects on feed intake and FCR values during in the trial. Marks (1981) reported that intakes on 20 and 28% dietary protein were, respectively, 12.2 and 15.7 g/day/bird and feed consumption increased with increasing protein level in diet. In our study, feed consumption and FCR values were similar to results of Konca et al. (17), Kilany and Mahmoud (20) and Macleod and Dabutha (22). Despite the increased water intake, feed consumption, live weight, ADG and FCR were all reduced in quail given Resin-treated Pine or other resin particles are used for disinfection and softening of waters in rural and forest areas in Turkey. The group given Acidic Resin-treated Water was the highest among the groups. Nain et al. (8) reported that the average daily consumption of water was 29.8 ml/bird on a 12:12 light: darkness program at 3 weeks of age. The water consumption of the female quail at 7 weeks of age was 55.37 g/day, and the daily water consumption/live weight ratio was 1.66 g/g determined by Minvielleet al. (7). In our experiment, the daily consumptions of water in all groups were similar to Marks (6), Nain et al. (8) and Minvielleet al. (7). The reason for the increased serum MDA of the Resin-treated Water group may have been because of decreased oxygen metabolism in cells because of acidic water. In addition, that group had increased water intake, decreased feed consumption and FCR. Wang et al. (23) reported that the effects of adding 3 g/kg of Arctiumlappa L. root in the diet reduced serum MDA to 7.51 nmol/ml compared to 9.21 nmol/ml in the control group, and also reduced serum SOD values to 215.72 U/ml versus 234.73 U/ml in the control. Hsu et al. (24) investigated the effects of 18 mg/kg of bacterial lycopene on oxidative stress in 100-day old laying quail were 52.3 μM of serum MDA in control group and 24.5 μM of the lycopene group and SOD values were 46.1 U/ml and 59.4 U/ml, respectively.Kilany and Mahmoud (20) found that 0.5% Turmeric (Curcuma longa L.) of diet were 0.68 μg/ml of the serum MDA, 160 U/ml of SOD and 58.75 U/ml of CAT in the quails. Researchers have reported that Turmeric reduced oxidative stress in quail, while serum MDA was lower than control group. Likewise SOD and CAT values were found to be higher than control group.

Table 4. Effects of water sources on the average live weight of Japanese quail, g/bird

Sources of Water	1.Week	2.Week	3.Week	4.Week	5.Week	6.Week	7.Week
Ozonated Water	21.67[bc]	59.43[a]	90.70[b]	136.80[b]	157.00[b]	171.68[b]	190.97[b]
Chlorinated Water	22.13[bc]	50.76[c]	86.20[bc]	130.50[c]	153.17[b]	167.67[bc]	187.03[b]
Celestite Stone-treated Water	20.26[c]	57.03[ab]	89.36[bc]	135.73[b]	153.90[b]	173.18[b]	190.20[b]
Natural Spring Water	23.46[a]	59.20[ab]	99.13[a]	147.46[a]	166.37[a]	182.90[a]	202.17[a]
Resin-treated Water	19.43[c]	49.93[c]	85.80[c]	126.73[d]	147.03[c]	163.23[c]	175.17[c]
P	0.050	0.001	0.001	0.001	0.001	0.001	0.001

[a,b,c]:The significant differences between the averages are shown by different letters on the same column.

Table 5. Effects of the water sources on average daily gain (ADG), feed intake and feed conversion rate (FCR) of Japanese quail

Sources of Water	ADG, g/day/bird			Feed Intake, g/day/bird			FCR, g/g		
	1-3 Weeks	4-7 Weeks	1-7 Weeks	1-3 Weeks	4-7 Weeks	1-7 Weeks	1-3 Weeks	4-7 Weeks	1-7 Weeks
Ozonated Water	4.32[b]	3.58[a]	3.90[b]	11.30[b]	22.51[b]	17.70[b]	2.62	6.30[b]	4.54[b]
Chlorinated Water	4.10[bc]	3.60[a]	3.82[b]	11.03[bc]	22.17[b]	17.40[b]	2.69	6.16[b]	4.56[b]
Celestite Stone-treated Water	4.25[bc]	3.60[a]	3.88[b]	11.70[b]	22.55[b]	17.90[b]	2.75	6.27[b]	4.61[b]
Natural Spring Water	4.72[a]	3.68[a]	4.13[a]	13.33[a]	25.51[a]	20.29[a]	2.82	6.93[a]	4.92[a]
Resin-treated Water	4.08[c]	3.19[b]	3.57[c]	10.17[c]	19.48[c]	15.49[c]	2.49	6.12[b]	4.33[c]
P	0.001	0.025	0.001	0.001	0.001	0.001	0.081	0.020	0.002

[a,b,c]:The significant differences between the averages are shown by different letters on the same column.

Table 6. Effects of water sources on average daily water intake of Japanese quail, g/day/bird

Sources of Water	1.Week	2.Week	3.Week	4.Week	5.Week	6.Week	7.Week	1-3 Weeks	4-7 Weeks	1-7 Weeks
Ozonated Water	11.00 ^{c}	26.43 ^{b}	34.76 ^{c}	39.50 ^{b}	44.53 ^{c}	53.23 ^{b}	57.73 ^{c}	24.06 ^{c}	48.76 ^{c}	38.16 ^{c}
Chlorinated Water	12.26 ^{ab}	26.26 ^{b}	34.73 ^{c}	38.56 ^{b}	43.26 ^{c}	52.06 ^{b}	55.26 ^{d}	24.43 ^{c}	47.30 ^{d}	37.50 ^{c}
Celestite Stone-treated Water	11.73 ^{bc}	26.43 ^{b}	34.46 ^{c}	39.36 ^{b}	43.83 ^{c}	54.43 ^{b}	58.23 ^{c}	24.26 ^{c}	48.96 ^{c}	38.36 ^{c}
Natural Spring Water	13.03 ^{a}	29.46 ^{a}	37.53 ^{b}	45.10 ^{a}	53.60 ^{a}	59.36 ^{a}	68.33 ^{a}	26.66 ^{b}	56.60 ^{a}	43.76 ^{a}
Resin-treated Water	13.40 ^{a}	31.13 ^{a}	40.16 ^{a}	43.30 ^{a}	48.60 ^{b}	58.30 ^{a}	64.96 ^{b}	28.23 ^{a}	53.83 ^{b}	42.83 ^{b}
P	0.005	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

^{a,b,c}:The Significant differences between the averages are shown by different letters on the same column.

Table 7. Effects of water sources on concentrations of serum MDA, SOD and CAT of Japanese quail

Sources of Water	MDA, µM/l	SOD, U/l	CAT, kU/l
Ozonated Water	2.07 ^{c}	45.15 ^{a}	60.40 ^{a}
Chlorinated Water	3.94 ^{bc}	30.31 ^{b}	44.20 ^{c}
Celestite Stone-treated Water	3.71 ^{bc}	31.80 ^{b}	39.74 ^{c}
Natural Spring Water	1.54 ^{d}	44.31 ^{a}	54.71 ^{b}
Resin-treated Water	4.27 ^{a}	19.24 ^{c}	32.57 ^{d}
P	0.001	0.001	0.001

^{a,b,c,d}:The significant differences between the averages are shown by different letters on thesame column.

Table 8. Effects of water sources on carcass parameters of Japanese quail

Sources of Water	Slaughter Weight, g	Hot Carcass Weight, g	Carcass Yield, %
Ozonated Water	192.17	139.97	72.86
Chlorinated Water	191.03	139.31	72.93
Celestite Stone-treated Water	190.01	138.99	73.20
Natural Spring Water	191.98	141.89	73.95
Resin-treated Water	188.42	138.83	73.69
p	0.399	0.647	0.904

We found no studies in the literature that examined effects of water type on these parameters. However, it can be said that these values are consistent with the values of carcass weight and carcass yield which are reported by Konca ve ark (17), Oguzet al. (25) and Yildirim and Ozturk (26).We have reached the following conclusions in the study: resin treatment did not make a significant contribution to disinfection and softening of the water. TDS appears to affect live weight, feed consumption and water content. Water varieties also affect oxidative stress in different ways. Results of the study indicate that, except for Resin-treated Water (which we do not recommend), supplying Natural Spring, Ozonated, Celestite Stone Waters or Chlorinated Water to growing Japanese quail yields satisfactory animal performance.

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