Journal of Animal and Veterinary Advances 11 (1): 43-51, 2012
ISSN: 1680-5593

Dietary Effects of Ca-Zeolite Supplementation on Water Consumption and Carcass Characteristics of Broilers

[1]H. Eleroglu and [2]H. Yalcin
[1]Sarkisla Asik Veysel Vocational High School,
Cumhuriyet University, 58400 Sivas, Turkey
[2]Department of Geological Engineering,
Cumhuriyet University, 58140 Sivas, Turkey

Abstract: The aim of this study was to ascertain the influence of natural Ca-zeolite consisting mainly of clinoptilolite and mordenite as a feed additive on the water consumption and some carcass characteristics of the broilers. One day old, 240 sexed Ross 208 broiler chicks obtained from a commercial hatchery were divided into 4 treatment groups of 60 birds each. Four experimental diets were tested with four levels of Ca-zeolite (0, 1, 3 and 5%) with completely randomized design with 3 replicates and 20 chicks per replicate and stocked with 14 birds m^{-2}. The usage of various levels Ca-zeolite in diets did not have any significant effect on water consumption, water/feed ratio (mL g^{-1}) during the 6 weeks trial and some carcass characteristics (live, cold carcass, drumstick, breast, wings, back, neck and edible giblets weights) in two sexes and mixed sex between the groups at 21 and 42 days of age ($p>0.05$). Feed consumption did not differ considerably between the groups in 6 weeks ($p>0.05$) but there are differences between the groups from 2-5 weeks ($p<0.05$). Ca-zeolite addition did not affect negatively viabilities in each group (95.55, 100.00, 100.00 and 100.00) ($p>0.05$). Finally, the values achieved by the addition of Ca-zeolite to broiler diets were usually in acceptable scale.

Key words: Clinoptilolite, mordenite, feed and water intake, viability, mortality, Turkey

INTRODUCTION

The use of natural clinoptilolites and mordenite have recently widened as a feed additive in broiler diets (Quarles, 1985; Olver, 1989). Zeolites used as a feed additive in broiler hybrid have mineralogical and structural differences. Some zeolites (for example erionite) morphological features (Accicular/fibrous) were analyzed showing the impact has been known that was probability carcinogenic. Therefore, the type of zeolite used in selection is important. The effects of zeolite may be observed due to its high molecular sieve adsorption capacity; effective selectivities for cations and ion-exchange capacity; hydration and dehydration; deodorizing properties and acid resistance. These may play a role in explaining the effectiveness of natural zeolites in agriculture (Mumpton, 1984; Tsitsishvili *et al*., 1992). It has been reported that zeolites can absorb the nitrogen of some amino acids, thus stabilizing them; they can reduce the energy required for the production of meat and also increase the utilization of calcium in the body (Quarles, 1985; Nestorov *et al*., 1985; Roland, 1990).

Water in addition to being a vital nutrient is involved in many aspects of poultry metabolism including body temperature control, digestion and absorption of food, transport of nutrients and the elimination of water products via urine from the body (Jafari *et al*., 2006). It is accepted to monitor daily water consumption of the birds by house as it can often be an early indication of a health problem and the water consumption may either increase or decrease compared to the standard consumption expected (Butcher *et al*., 1999). Water consumption can be affected by issues of feed quality such as feed composition and suitability, feed type, feed intake and mycotoxin contamination (Manning *et al*., 2007a).

In animals, the optimum growth, producing and for effective feed efficiency are needed consistently high quality water (Scott *et al*., 1982). Feed consumption and water intake are located in a strong relationship between water consumption that also decreases with decreasing feed intake (Sykes, 1983; Duke, 1986). The poultry producers were interested in the harmful effects of water content as well as harmful effects. A difference in the structure of water was caused by different production results (Eleroglu and Sarica, 2004). Many factors are known to affect water intake such as genetic, dietary salt concentration, source and concentration of dietary protein and physical form of the diets. Water intake is more dependent on the availability of feed than feed is on the availability of water (Marks and Brody, 1984). Zeolite

Corresponding Author: H. Eleroglu, Sarkisla Asik, Veysel Vocational High School, Cumhuriyet University, 58400 Sivas, Turkey

supplemented diets are well tolerated by the animals and they support biomass production and improve the health status of the animals (Martin-Kleiner *et al*., 2001; Papaioannou *et al*., 2004).

The main aim of the presented research was to investigate the effect of Ca-zeolite as a feed supplement on the water/feed consumption, viability and carcass characteristics of broilers during their growth at defined experimental conditions.

MATERIALS AND METHODS

Zeolite: The zeolite used in this study was provided from well-defined zeolitic tuff of Eocene age in the Sivas-Yavu region of Turkey (Yalcin, 1997). Mineralogical assemblages were determined on bulk samples by means of a Rigaku DMAX IIIC automated diffractometer at Cumhuriyet University, Sivas. The material added to the basal diet during this investigation was comprised mainly of clinoptilolite (50%), mordenite (40%), quartz (5%), feldspar (5%) and trace amounts of smectitic clay. X-ray diffraction pattern and morphologies of zeolites were largely explained in another application (Eleroglu and Yalcin, 2005). The samples were analyzed at the Activation Laboratories Ltd. (Actlabs, Ancaster, Canada) for major oxides and trace element contents using Inductively Coupled Plasma-Mass Spectrometer (ICP-MS).

SiO_2, Al_2O_3 and H_2O related to loss on ignition and CaO are the essential oxides of zeolitic material and Fe_2O_3 and MgO are represented in minor concentrations (Table 1). Heulandite/clinoptilolite and mordenite bearing tuffs are quite richer in alkaline earth elements such as chiefly Ca insignificant Sr and Ba rather than alkali ones such as Na and K. The ratios of some oxides as $SiO_2/(Al_2O_3+Fe_2O_3)$, $(Na_2O+K_2O)/(CaO+MgO+BaO+SrO)$ and Na_2O/K_2O are 4.68, 0.29 and 1.42, respectively that can be nomenclatured as Ca-zeolite by eliminating of very small impurities such as quartz, feldspar and clay. Further transition metals and other tracers have not of note amounts in the composition of zeolite.

Table 1: Chemical composition of the natural zeolitic volcanic tuff used in the experiment

Major oxides (wt. %)	Values	Trace elements ($mg\ kg^{-1}$)	Values	Trace elements ($mg\ kg^{-1}$)	Values
SiO_2	63.820	Cr	60	Sb	1
TiO_2	0.297	Ni	20	Rb	17
Al_2O_3	11.720	Co	3	Ba	1255
ΣFe_2O_3	1.920	Sc	7	Sr	3571
MnO	0.022	V	31	Ga	13
MgO	1.040	Cu	10	Nb	10
CaO	4.110	Pb	22	Hf	5
Na_2O	0.950	Zn	40	Zr	194
K_2O	0.670	Sn	4	Y	30
P_2O_5	0.070	W	1	Th	13
LOI	14.840	As	9	U	2

ΣFe_2O_3 = Total iron, LOI = Loss on Ignition at 1000°C

Animal and feeding: About 240 days old sexed broiler (Ross 208 strain) chicks were obtained from a commercial hatchery from Kayseri Yemsel Company, Turkey. The birds were randomly distributed into 12 pens each with 10 males and 10 females. There were 4 dietary treatments, each containing 3 replicate pens. The experiment was conducted in completely randomized design. Two maize-soybean meal basal diets (Starter 0-11 days, grower 11-21-35 days and finisher 35-42 days) were formulated to provide adequate levels of all nutrients for broilers (NRC, 1994; Table 2). The diets of starter phase (0-11 days) were calculated that contain 23% Crude Protein (CP) and 3.040 kcal of Metabolizable Energy (ME) per kg of diet; 21.5% CP and 3.140 kcal of ME per kg of diet for the grower phase 1; 20.5% CP and 3.180 kcal of ME per kg of diet for the grower phase 2 and 19% CP and 3.220 kcal of ME per kg of diet for the finisher phase. The basal diets as control groups were supplemented with 4 levels of Ca-zeolite (0, 1, 3 and 5%) to provide 0, 10, 30 and

Table 2: Ingredients and composition of experimental diets (%)

	Days			
Feed ingredients	0-11	11-21	21-35	35-42
Corn	54.290	55.280	57.68	61.660
Soybean meal	16.200	11.480	8.21	4.200
Full-fat soybean	16.000	20.000	21.00	21.000
Chicken meal	3.900	3.900	3.90	3.900
Sunflower meal	3.000	3.000	3.00	3.000
Meat-bone meal	2.460	2.600	2.60	2.600
Vegetable oil	1.110	2.180	2.30	2.480
Fish meal	1.000	-	-	-
Marble powder	0.600	0.520	0.43	0.250
Vitamin-mineral premix*	0.300	0.250	0.25	0.200
DL-methionine	0.270	0.210	0.15	0.150
Lysine	0.240	0.110	0.07	0.072
Salt	0.100	0.100	0.12	0.110
Vitamin D_3	0.100	0.075	0.04	-
Vitamin-E	0.050	-	-	0.100
Enzyme	0.100	0.100	0.100	0.100
Sodium bicarbonate	0.075	0.071	0.057	0.075
Choline chloride	0.070	0.070	0.050	0.050
Anticoccidiostat	0.050	0.050	0.050	-
Toxin binder	0.050	-	-	-
Calculated nutrients composition (%)				
ME ($kcal\ kg^{-1}$)	3040.000	3140.000	3180.00	3220.000
Crude protein	23.000	21.500	20.50	19.000
Crude cellulose	4.440	4.520	4.49	4.480
Crude ash	6.070	5.710	5.43	5.100
Ether extract	8.910	10.610	10.93	11.310
Lysine	1.500	1.300	1.20	1.100
Methionine	0.610	0.530	0.46	0.440
Methionine+cystine	1.080	0.980	0.90	0.860
Threonine	0.980	0.880	0.84	0.780
Calcium	1.050	0.950	0.90	0.800
Total phosphorus	0.760	0.720	0.71	0.670
Available phosphorus	0.500	0.460	0.46	0.430

Each kg of vitamin-mineral premix contained: Vitamin A, 4.400.000 IU; vitamin D_3, 1.600.000 IU; vitamin E, 20.000 mg; vitamin K_3, 1.600 mg; vitamin B_1, 1.200 mg; vitamin B_2, 3.200 mg; vitamin B_3, 20.000 mg; vitamin B_5, 6.000 mg; vitamin B_6, 1.600 mg; vitamin B_9, 800 mg; vitamin B_{12}, 8 mg; biotin, 80 mg; antioxidant dry, 50.000 mg; Cu, 6.000 mg; Fe, 20.000 mg; Mn, 48.000 mg; Se, 80 mg; Zn, 40.000 mg; Co, 80 mg; I, 500 mg

50 g kg^{-1} of total Ca-zeolite in the diet. All basal feed and water were supplied *ad libitum* for all chicks during experimental works. A broiler house was divided into 12 sections with 2×1×1 m (length x width x height) in dimensions and separated by mesh wire fences that were prevented air exchange between sections and stocked density with 14 birds m^{-2}. Its preparation was fulfilled as specified by Turkoglu and Sarica (2009) prior to introduction of the chicks. The interior of the broiler house was naturally ventilated. The treatment groups were randomly distributed in the houses and the same airflow was provided. The temperature was maintained at 32°C during the 1st week and then was reduced by 3°C $week^{-1}$ until 20°C was reached and this temperature was protected until the end of the testing. The birds were exposed to light for 24 h during the 1st 3 days and then 23.5 h light and 30 min dark daily until the slaughter age. Feed and water containers were placed in each section and fresh water was provided *ad libitum*. Suspended plastic feeder and plastic nipple with drip cups were utilized in each section for the 1st 10 days after using one drinking cups for chicks and flat chick feeders. For each division was mounted to measure water consumption one cylindrical, scaled, rigid and good temperature tolerance, 10 L capacity tanks with hard surfaces. Feed was weighed and added by depending on the feed containers when levels were dropped. The heights of both the feed and the water containers were adjusted as the chickens grew. The content of the water used in this research are shown in Table 3.

Carcass traits measurement: At 21 and 42 days of age, twelve birds (six males and six females) per treatment were randomly selected, weighed and slaughtered for carcass evaluation. After slaughter, birds were eviscerated and carcasses were cooled for 24 h, 4°C and then were measured cold carcass weight. Carcass parts weight as drumstick, breast, wings, back, neck and edible giblets were determined according to rules of TSE (1987).

Statistical analysis: Data were analyzed by a completely randomized design within water consumption, carcass characteristics and feed consumption groups based on the GLM procedure of Minitab software (Minitab, 2000). Results were offered as mean±SEM and differences among treatment means were compared by Duncan's multiple-range test.

Table 3: Ingredients of experimental water

Characteristic	Amounts	Acceptable level*
pH	7.63	6.5-8.5
Total hardness (F.S.)	15.20	<100 soft
Chloride (mg L^{-1})	8.67	250
Sulfate (mg L^{-1})	33.37	50-200
Nitrate (mg L^{-1})	2.84	10 mg L^{-1}
Nitrite (mg L^{-1})	-	0.4 mg L^{-1}
Calcium (mg L^{-1})	38.91	<600
Magnesium (mg L^{-1})	13.30	50-125
Copper (μg L^{-1})	1.62	0.002 mg L^{-1}
Iron (μg L^{-1})	29.56	<0.3 mg L^{-1}
Lead (mg L^{-1})	-	0.2 mg L^{-1}
Sodium (mg L^{-1})	14.13	50-300
Zinc (μg L^{-1})	9.65	Trace

*Eleroglu and Sarica (2004); Debortoli (2005); Carter *et al.* (2010)

RESULTS AND DISCUSSION

The effects of adding different levels of Ca-zeolite in the broiler diets on the water consumption, feed intake and water/feed (mL g^{-1}) ratio are shown in Fig. 1 and Table 4-6, respectively. Ca-zeolite addition did not affect water consumption and water/feed ratio in each group (p>0.05).

Feed intake did not differ significantly between the groups in 6 weeks (p>0.05) but there are differences between the groups from 2-5 weeks (p<0.05). Effect of dietary supplementation of different levels of Ca-zeolite on some carcass characteristics at 3 and 6 weeks of age are shown in Table 7 and 8, respectively.

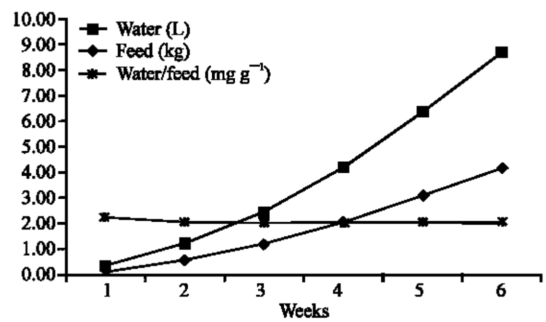

Fig. 1: Water consumption (L), Feed consumption (g) ve Water/feed (mL g^{-1}) ratio

Table 4: Effect of dietary supplementation of different levels zeolite on water consumption (L)*

Age (weeks)	Groups: Control	1% Zeolite	3% Zeolite	5% Zeolite
1	372.33±0.580	359.25±24.50	373.08±1.390	374.54±7.100
2	1214.00±19.60	1238.40±79.40	1246.10±18.90	1239.70±40.30
3	2412.90±98.20	2394.20±74.40	2458.10±156.5	2465.80±89.80
4	4323.40±293.9	4081.80±179.1	4217.90±268.7	4168.60±188.7
5	6607.70±214.1	6171.30±211.1	6334.00±343.1	6286.90±343.8
6	8943.30±515.1	8537.00±238.8	8501.10±431.6	8583.70±454.0

*Differences not significant (p>0.05)

Table 5: Effect of dietary supplementation of different levels zeolite on feed consumption (g)*

Age (weeks)	Groups: Control	1% Zeolite	3% Zeolite	5% Zeolite
1	164.68±1.240^a	164.04±1.970^a	163.91±1.020^a	163.37±4.530^a
2	605.52±2.800^a	601.98±2.980^a	608.70±9.080^a	589.71±3.910^b
3	1210.00±5.900^a	1204.10±14.60^a	1214.40±14.90^a	1179.20±15.90^b
4	2126.60±14.20^a	2102.20±14.70^a	2027.90±33.30^b	2031.70±25.70^b
5	3108.10±25.60^a	3099.60±11.10^a	3117.40±43.70^a	3011.80±41.20^b
6	4170.80±61.20^a	4203.10±81.30^a	4153.40±41.50^a	4113.10±15.20^a

*Means within the row with superscripts, a-b, differ significantly at p>0.05

There are no considerable differences in live, cold carcass, drumstick, breast, wings, back, neck, edible giblets (heart, gizzard and liver) weights and relative organs at 3 and 6 weeks of slaughter age (p>0.05). The viability of the birds in the treatment groups is shown in Table 9. No significant difference (p>0.05) was observed between the average values obtained. The basis of interest in the biological effects of zeolites concerns one or more of their physical and chemical properties such as ion exchange capacity, adsorption and related molecular sieve properties (Papaioannou *et al*., 2005). There has been evidence that zeolites has beneficial effect on feed efficiency ratio, water consumption, nutrient utilization, manure and litter condition and more importantly on aflatoxicosis (Shariatmadari, 2008). However, one of the major concerns which the use of natural zeolites in animal nutrition arises is their potential adsorbent and binding effect on essential nutrients such as vitamins and minerals (Pasteiner, 1998). In such case if large quantities of these elements are rendered

Table 6: Effect of dietary supplementation of different levels zeolite on water/feed (mL g^{-1}) ratio*

	Groups			
Age (weeks)	Control	1% Zeolite	3% Zeolite	5% Zeolite
1	2.26	2.19	2.28	2.29
2	2.00	2.06	2.05	2.10
3	1.99	1.99	2.02	2.09
4	2.03	1.94	2.08	2.05
5	2.13	1.99	2.03	2.09
6	2.14	2.03	2.05	2.09

* Differences not significant (p>0.05)

Table 7: Effect of dietary supplementation of different levels zeolite on some carcass characteristics at 3 weeks of age*

		Groups			
Carcass characteristics	Sex**	Control	1% Zeolite	3% Zeolite	5% Zeolite
Live weight (g)	M	888.80±47.2000	894.70±35.1000	916.200±79.000	862.30±80.900
	F	767.33±65.6700	773.00±38.8000	777.17±51.2900	810.67±54.280
	Mixed	828.08±53.7500	833.83±25.7200	846.67±14.9100	836.50±66.630
Cold carcas weight (g)	M	639.32±37.3900	642.77±53.5300	670.18±45.2900	620.05±59.130
	F	550.00±50.3100	578.62±10.7300	548.41±72.3600	581.90±38.650
	Mixed	594.66±43.6500	610.70±31.3800	609.08±13.7400	600.98±46.630
Carcass yield (%)	M	71.973±1.7890	71.773±3.1600	73.183±1.4500	71.943±0.640
	F	71.637±0.3610	75.110±3.5840	70.470±4.5650	71.823±1.823
	Mixed	71.803±1.0180	73.440±2.9190	71.823±2.9560	71.883±1.150
Drumstick weight (g)	M	178.28±9.32000	179.08±8.59000	189.77±10.7900	184.97±15.450
	F	155.38±20.8200	152.98±11.7700	147.18±20.6900	156.70±11.110
	Mixed	166.84±14.9400	166.03±9.91000	168.48±12.1200	170.84±11.480
Drumstick (%)	M	27.940±0.3240	27.927±1.0260	28.477±2.3490	29.810±0.940
	F	28.137±1.2350	26.447±1.5520	26.860±0.8150	26.923±0.178
	Mixed	28.043±0.6400	27.187±0.4310	27.670±1.5170	28.367±0.389
Breast weight (g)	M	153.23±7.25000	146.65±14.9100	164.35±19.4600	144.07±12.230
	F	134.52±23.0800	137.90±4.19000	131.45±24.1500	136.78±5.3100
	Mixed	143.88±14.3700	142.28±7.45000	147.90±3.94000	140.43±3.4900
Breast (%)	M	23.937±0.2740	22.997±3.2430	24.403±1.2460	23.247±0.341
	F	24.523±3.7400	23.853±1.0940	23.923±1.4170	23.593±2.316
	Mixed	24.233±1.9060	23.423±2.0700	24.160±0.3650	23.420±1.266
Wings weight (g)	M	71.617±5.0020	66.900±2.0320	74.900±0.6730	71.233±4.861
	F	60.500±7.6110	68.300±5.1720	63.167±5.6180	65.800±1.900
	Mixed	66.060±5.5890	67.603±3.2440	69.037±2.4780	68.520±3.304
Wings (%)	M	1.217±0.2100	10.517±1.1550	11.270±0.6410	11.483±0.397
	F	10.993±0.7710	11.807±0.9500	11.573±0.6720	11.330±0.442
	Mixed	11.107±0.2920	11.167±0.7490	11.420±0.1760	11.410±0.409
Back weight (g)	M	203.08±19.0400	219.28±18.2100	210.87±26.9300	192.82±24.360
	F	174.85±18.4200	189.93±3.56000	180.15±23.0600	192.97±29.250
	Mixed	188.97±18.2100	204.61±7.38000	195.51±6.81000	192.89±26.570
Back (%)	M	31.707±1.7490	34.423±2.0700	31.337±2.7040	31.090±1.118
	F	31.807±2.7560	32.787±0.8950	32.827±0.3690	33.060±2.777
	Mixed	31.753±2.0530	33.603±1.2280	32.083±1.5360	32.073±1.935
Neck weight (g)	M	29.817±5.0010	23.850±1.8360	28.567±2.0890	24.667±1.168
	F	23.767±1.0300	27.100±4.6210	23.767±1.4190	26.467±2.458
	Mixed	26.793±2.9930	25.477±3.0560	26.170±0.3350	25.567±1.388
Neck (%)	M	4.6633±0.705	3.7200±0.213	4.2733±0.379	4.0167±0.186
	F	4.3533±0.289	4.6800±0.751	4.3833±0.660	4.5433±0.310
	Mixed	4.5100±0.451	4.1967±0.340	4.3300±0.174	4.2833±0.214
Edible giblets weight (g)	M	51.600±2.5940	55.667±0.3750	56.067±5.4170	55.167±9.226
	F	49.033±7.1460	47.583±5.0320	50.817±7.7860	53.683±7.775
	Mixed	50.317±3.3360	51.630±2.6750	53.443±3.8650	54.427±5.639
Edible giblets (%)	M	8.123±0.9010	8.720±0.7370	8.327±0.1330	9.040±2.119
	F	8.930±0.8670	8.227±0.8560	9.330±1.3630	9.237±1.373
	Mixed	8.530±0.6680	8.473±0.7010	8.827±0.7290	9.140±1.272

*Differences not significant (p>0.05); ** Sex: M = Male; F = Female; (%) Values are calculated according to the weight of cold carcass

Table 8: Effect of dietary supplementation of different levels zeolite on some carcass characteristics at 6 weeks of age*

Carcass characteristics	Sex**	Control	1% Zeolite	3% Zeolite	5% Zeolite
Live weight (g)	M	2657.5±203.800	2690.8±114.1000	2602.50±69.1000	2669.30±166.000
	F	2288.3±98.4000	2266.70±41.4000	2320.8±148.1000	2164.20±64.3000
	Mixed	2472.9±52.7000	2478.80±42.6000	2461.70±107.000	2416.70±59.3000
Cold carcas weight (g)	M	1966.5±143.400	1948.0±103.3000	1924.90±40.3000	2014.6±143.6000
	F	1721.7±95.5000	1695.80±15.0000	1667.9±116.1000	1608.20±17.6000
	Mixed	1844.10±32.2000	1821.90±57.8000	1796.400±77.000	1811.40±68.9000
Carcass yield (%)	M	74.053±1.1350	72.400±1.8010	73.990±0.8330	75.390±0.7590
	F	74.233±1.3230	74.853±1.4090	71.750±2.0660	74.150±2.4590
	Mixed	74.647±1.1410	73.627±1.1660	72.867±1.4280	74.773±1.5590
Drum stick weight (g)	M	581.42±48.9800	586.78±35.4800	560.32±17.1500	607.20±45.4600
	F	480.47±32.0600	482.40±2.74000	481.30±38.0400	466.52±12.9800
	Mixed	530.95±14.6500	534.59±18.8600	520.81±26.2100	536.86±29.0600
Drum stick (%)	M	29.540±1.1150	30.113±0.2350	29.097±0.3190	30.157±0.2720
	F	27.893±1.2590	28.450±0.2460	28.923±0.8010	28.833±0.8550
	Mixed	28.720±0.3120	29.280±0.1310	29.010±0.4230	29.493±0.4640
Breast weight (g)	M	595.87±57.9900	572.37±24.0500	635.58±27.5700	614.72±43.6300
	F	543.05±26.2600	516.05±35.4700	505.22±60.2800	509.62±25.1200
	Mixed	569.46±21.2300	544.21±15.9300	570.40±43.0500	562.17±12.0300
Breast (%)	M	30.347±0.8040	29.387±0.3780	31.340±0.8070	30.403±0.9250
	F	31.583±0.9240	30.427±2.3200	30.283±2.4060	31.770±1.1820
	Mixed	30.970±0.6640	29.910±1.1680	31.647±1.4140	31.087±0.5850
Wings weight (g)	M	208.47±14.1800	210.95±4.83000	206.08±16.8100	215.52±6.52000
	F	193.70±21.6200	186.15±7.19000	196.72±5.04000	173.98±6.53000
	Mixed	201.09±5.59000	198.55±5.05000	201.40±5.96000	194.75±6.38000
Wings (%)	M	10.617±0.1440	10.863±0.5890	10.693±0.7260	10.720±0.6600
	F	11.250±0.8600	10.987±0.3590	11.853±1.2300	10.907±0.3660
	Mixed	10.930±0.5030	10.927±0.2300	11.277±0.3620	10.813±0.2160
Back weight (g)	M	450.07±39.3200	450.93±41.9300	396.65±15.5600	448.25±50.0200
	F	389.38±30.2600	405.13±35.2500	373.02±42.0300	352.62±25.3000
	Mixed	419.73±13.5600	428.04±33.5500	384.84±18.6600	400.44±12.4400
Back (%)	M	22.830±1.7980	23.113±0.9060	20.643±1.2740	22.327±1.3770
	F	22.593±1.1280	23.883±1.8940	22.277±1.8290	21.910±1.4350
	Mixed	22.710±0.6200	23.493±1.2010	21.460±1.2040	22.120±0.3580
Neck weight (g)	M	127.50±10.1700	127.23±3.66000	121.75±15.4900	127.68±16.9200
	F	107.43±2.61000	105.92±18.9300	109.37±13.6600	102.50±18.2800
	Mixed	117.47±5.41000	116.58±11.2400	115.56±9.23000	115.09±14.1300
Neck (%)	M	6.5000±0.075	6.5467±0.395	6.3300±0.858	6.3400±0.720
	F	6.2500±0.338	6.2467±1.092	6.5200±0.435	6.3900±1.125
	Mixed	6.3767±0.162	6.3933±0.710	6.4233±0.471	6.3633±0.598
Edible giblets weight (g)	M	126.40±7.04000	126.95±6.16000	117.020±5.8000	121.82±1.62000
	F	124.35±11.6500	120.68±5.76000	117.05±10.3500	115.23±10.3500
	Mixed	125.38±7.29000	123.82±1.95000	117.04±2.87000	118.53±5.12000
Edible giblets (%)	M	6.4433±0.376	6.5300±0.075	6.0867±0.220	6.0600±0.445
	F	7.2400±0.948	7.1167±0.411	7.1500±1.116	7.2533±0.482
	Mixed	6.8433±0.332	6.8233±0.231	6.6200±0.460	6.6567±0.460

*Differences not significant (p>0.05); ** Sex: M = Male; F = Female (%). Values are calculated according to the weight of cold carcass

Table 9: The viability of the birds in the treatment groups (%)

Age (weeks)	Control	1% Zeolite	3% Zeolite	5% Zeolite
1	100.00±0.00	100.00±0.00	100.00±0.00	98.25±3.04
2	100.00±0.00	100.00±0.00	98.33±2.89	98.33±2.89
3	98.33±2.89	100.00±0.00	100.00±0.00	96.39±3.13
4	98.33±2.89	100.00±0.00	98.25±3.04	98.15±3.21
5	100.00±0.00	100.00±0.00	95.54±3.89	100.00±0.00
6	95.55±3.85	100.00±0.00	100.00±0.00	100.00±0.00

unavailable to the animals via feed in a long-term basis, the caused nutritional imbalances might have a non-desired effect on both performance and health status preservation. In order to estimate whether the requirements for essential elements are met, the absorbable or utilizable/available amounts are considered rather than the total amounts in feed ingredients. Chickens consume about twice as much water as food (1.8:1 at a temperature of 21°C in bell drinkers) although, this ratio can be much higher during hot conditions (NRC, 1994; Turkoglu and Sarica, 2009). However in heat-stressed birds this level will be increased. Water intake of a chicken will increase by 6-7% for each degree >21°C and is closely linked to feed intake and bird age. As the bird gets older, the demand for water will raise (Bailey, 1999). Lott *et al.* (2003) estimate the correlation between feed and water consumption at 0.98. An increase or decrease from expected water consumption levels can be an indication of a health problem (Butcher *et al.*, 1999). Research results obtained from the total consumption of water, feed consumption values and water/feed (mL g^{-1}) ratio around specified limits (NRC, 1994; GEORGIA, 2001; Manning *et al*., 2007b; Turkoglu and Sarica, 2009) remained and show no health problems (Butcher *et al*., 1999). Within the limits of the water content to be used in the study reported (Eleroglu and Sarica, 2004) from the consumption of water and water/feed (mL g^{-1}) ratio to remain within the limits prescribed contribution.

Some previous researchs demonstrated that there is a relationship between feed and water consumption (GEORGIA, 2001; Lott *et al*., 2003). The volume of water consumed by birds is influenced by a number of differing and even cumulative factors. Water usage has historically been measured in Liters/bird/cycle or Liters/1000 birds day^{-1}. These indicators can reveal a sudden rise or fall in water consumption which can then be investigated. The ratio between feed and water consumption also gives an indication of performance (Manning *et al*., 2007b). It also stated that the feed: water ratio varied between 1.5:1 in Winter and 1.77:1 in Summer (GEORGIA, 2001).

The ratio between feed and water consumption not only varied between Summer and Winter production but also between production systems and sites. The ratio was 1.65 in the Winter and 1.72 in the Summer and for the larger birds which was between 1.62 and 1.93 showed much greater variance across the crop cycles. There was also a larger deviation in the Summer than in the Winter months (Manning *et al*., 2007b).

Among the many studies conducted regarding zeolites effects on all aspect of poultry performances, there has been little attempt to measure whether zeolite has any effect on water intake. Of these, Onagi (1965) demonstrated that water consumption as well as moisture content of litter were reduced when zeolite was included in the diet of broiler chickens (Mumpton and Fishman, 1977). There was no explanation as to why zeolite should have adverse effects on water consumption (Shariatmadari, 2008).

In particular, the presence of inorganic elements such as sodium (Na), potassium (K) and Chloride (Cl) will be associated with increased water consumption. Thusly, Watkins *et al*. (2005) reported that levels of Na and Cl in drinking water and in the diet significantly affected live performance of broilers with a significant interaction between dietary and water levels. Barton *et al*. (1986) confirmed that elements in the water had significant ($p<0.05$) correlation (r) to feed conversion (Magnesium positive r; calcium negative r), body weight (Dissolved oxygen, bicarbonate, hardness and magnesium positive r; nitrate negative r), livability (Calcium and potassium negative r) and condemnation (Calcium and nitrate negative r). Barton *et al*. (1986) suggested that growth performance was related to the aggregate of elements in the water as well as high or low levels of specific elements. This event was supported by Zimmermann *et al*. (1991) when an experiment with elevated dissolved oxygen in the water failed to improve broiler body weight. In this case, the effect of the zeolite will depend on the content of feed and water.

The effect of dietary zeolites on feed intake varies according to researchers with an increase in feed intake reported by Olver (1989), no effect (Roland *et al*., 1985) and reduced feed intake (Miles *et al*., 1986). The best attribute given to zeolite is its beneficial effect on feed efficiency in both layers and broiler chickens (Shariatmadari, 2008). There seems to be a general agreement on this issue (Oliver, 1997), although a few reports suggested that zeolite had no beneficial effect (Vest and Shutze, 1984; Min *et al*., 1988; Cornejo *et al*., 1995; Wihandoyo *et al*., 2001; Moghaddam *et al*., 2005; Khajali *et al*., 2006; Safaeikatouli *et al*., 2010) or even had a negative effect on this parameter (Nakaue and Koelliker, 1981).

Live weight, cold carcass weight and some carcass characteristics in two and mixed sexes between the groups at 21 and 42 days of age are shown Table 7 and 8. No significant differences ($p>0.05$) were noted among all treatments for carcass yield and percentage of drumstick, breast, wings, back, neck and edible giblets (Heart, gizzard and liver) weights. The accent in broiler production is putting on the quality and yield of the carcass parts. There are several factors which have an influence on these parts such as line, sex, age, health, nutrition, body weight, carcass estimation and period of terminated nutrition before slaughtering (Siegel, 1984; Nikolova and Pavlovski, 2009). But nutrition in all factors also has directly effect on concerned quality parameters. Likewise, nutrition is the first anticipated factors of all breeding condition. Carcass weight and composition of broiler chickens are receiving considerable attention (Ng'ambi *et al*., 2009). There is an emphasis on increasing the meat yield, especially breast meat and decreasing the fat content of the broiler chicken carcass (Bedford and Summers 1985; Hickling *et al*., 1990; Kerr *et al*., 1999; Rezaei *et al*., 2004). Zeolite supplementation levels used in the broiler diets were not caused the discrepancies in carcass traits. Means of groups showed so close values to each other in terms of carcass weight. The result of this study confirmed that of Ozturk *et al*. (1996) who obtained no effect of dietary zeolite on carcass weight, dressing percentage, edible giblets (Heart, gizzard and liver) and parts yield. Similarly, Khajali *et al*. (2006) investigated the effect of natural zeolite (0, 1.5, 3 and 4.5%) on carcass, breast and thigh yields of both male and female broiler chickens and concluded that the dietary intake of this substance have any insignificant role on the dependent variables under study. Wihandoyo *et al*. (2001) and Moghaddam *et al*. (2005) also examining the effect of dietary zeolite (1, 3 and 5%) showed that adding this substance to diet have no large influence on carcass weight of broilers. On the other hand, Zainuddin (1995) observed that different levels of zeolite (0, 2.5, 5 and 7.5%) in quail ration resulted non significant effect on carcass percentage. Min *et al*. (1988) and Cornejo *et al*. (1995) defined a similar influence of added zeolite (2, 4 and 6%) on carcass weight and yield of broilers among treatments ($p>0.05$). Fisinin *et al*. (1985) found that clinoptilolite supplementation at the level of 5% raising meat yield. In another study it is claimed that the addition of zeolite had no major differences in internal organs (Heart and liver) between trial groups and control (Safaeikatouli *et al*., 2010). Prvulovic *et al*. (2008) reported that the weight of the other measured organs was not affected by the dietary treatment.

Viability results were reflected in agreement with the studies of some researches (Willis *et al*., 1982; Fisinin *et al*., 1985; Cornejo *et al*., 1995; Alcicek *et al*., 1998; Cabuk *et al*., 2004) who showed that mortality was with <5% during experiments. However, Karelina reported that supplementation different levels of natural zeolite increased the viability of broilers. The results in term of the values of viability remained within acceptable limits, it could be thought that Ca-zeolite used in the test maintaining it in an available form did not cause any toxic effect.

CONCLUSION

It was found that Ca-zeolite supplementation in different levels used in the diets of both sexes broiler present similar nutrition behavior and carcass traits between treatments at the same trial condition. As a conclusion, the values obtained by the addition of Ca-zeolite to broiler diets were generally in acceptable scale. In addition, experiments in broilers at various testing conditions are required to determine the effect of various natural zeolite types with different ratios of tetrahedral (Si/Al+Fe) and exchangeable cations (Na+K/Ca+Mg+Ba+Sr and Na/K), H_2O content in the pores and some physical properties such as ion-exchange capacity and channel dimensions.

ACKNOWLEDGEMENTS

Unit of the Scientific Research Projects of Cumhuriyet University in Sivas from Turkey supported all of the research for this study (Project No. ENF-002). Some analysis was performed at the laboratories of Faculty of Medicine. The researchers would like to thank Ahmet AKER who kindly provided assistance with the preparation of brolier samples.

REFERENCES

Alcicek, A., M. Bozkurt, K. Ozkan, A. Altan, M. Cabuk, Y. Akbas and O. Altan, 1998. Utilisation of natural zeolit in poultry. II. Effect of zeolite supplementation on broiler performance, some tibia and blood serum parameters. Ege Univ. J. Agric. Fac., 35: 17-24.

Bailey, M., 1999. The Water Requirements of Poultry. In: Recent Developments in Poultry Nutrition 2, Wiseman, J. and P.C. Garnsworthy (Eds.). Nottingham University Press, UK., pp: 321-337.

Barton, T.L., L.H. Hileman and T.S. Nelson, 1986. A survey of water quality on Arkansas broiler farms and its effect on performance. Proceedings of the 21st Mtg. on Poultry Health and Condemnations, (PHC'86), University of Arkansas, Fayetteville, AR. USA., pp: 1-33.

Bedford, M.R. and J.D. Summers, 1985. Influence of the ratio of essential to nonessential amino acids on performance and carcass composition of the broiler chick. Br. Poul. Sci., 26: 483-491.

Butcher, G.D., J.P. Jacob and F.B. Mather, 1999. Common poultry diseases. Fact Sheet No. PS-47, University of Florida. http://edis.ifas.ufl.edu/ps044.

Cabuk, M., A. Alcicek, M. Bozkurt and S. Akkan, 2004. Effect of yucca schidigera and natural zeolite on broiler performance. Int. J. Poult. Sci., 3: 651-654.

Carter, T.A., E. Ronald and R.E. Sneed, 2010. Drinking water quality for poultry. http: //www. ces.ncsu.edu/ depts/poulsci/tech_manuals/drinking_water_quality.html.

Cornejo, V., S.E.A. Klohn, O.H. Hidalgo and R.J. Pokniak, 1995. Inclusion of natural clinoptilolite in diets for broiler chickens. Avences Ciencias Veterinarias, 10: 32-37.

Debortoli, C.A., 2005. Water quality. Ross Tech 08/47, Scotland, UK.

Duke, G.E., 1986. Alimentary Canal: Anatomy, Regulation of Feeding and Motility. In: Avian Physiology, Sturkie, P.D. (Ed.). Springer Verlag, New York, pp: 269-288.

Eleroglu, H. and H. Yalcin, 2005. Use of natural zeolite-supplemented litter increased broiler production. S. Afr. J. Anim. Sci., 35: 90-97.

Eleroglu, H. and M. Sarica, 2004. Water quality in poultry production. Proceedings of the 4th National Animal Science Congress, Sept. 1-3, Department of Animal Science, Faculty of Agriculture, Suleyman Demirel University, Isparta, Turkey, pp: 318-324.

Fisinin, V., V. Agecv, O. Sintserova, T. Lenkova and N. Kvashali, 1985. Zeolites in diets for poultry. Ptitsevodstvo, 9: 2-26.

GEORGIA, 2001. Water usage and broiler performance. The University of Georgia-Cooperative Extension Service, College of Agricultural and Environmental Sciences, University of Georgia.

Hickling, D., W. Geuenter and M.E. Jackson, 1990. The effects of dietary methionine and lysine on broiler chicken performance and breast meat yield. Can. J. Anim. Sci., 70: 673-678.

Jafari, R.A., A. Fazlara and M. Govahi, 2006. An investigation into *Salmonella* and fecal coliform contamination of drinking water in broiler farms in Iran. Int. J. Poult. Sci., 5: 491-493.

Kerr, B.J., M.T. Kidd, K.M. Halpin, G.W. McWard and C.L. Quarles, 1999. Lysine level increases live performance and breast yield in male broilers. J. Applied Poult. Res., 8: 381-390.

Khajali, F., A.A.K. Zamani Moghadam and S. Habibi, 2006. Effects of different levels of natural zeolite on broiler performance and carcass characteristics. Univ. Tabriz J. Agric. Sci., 16: 165-174.

Lott, B.D., W.A. Dozier, J.D. Simmons and W.B. Roush, 2003. Water flow rates in commercial broiler houses. Poult. Sci., 82: 102-102.

Manning, L., S.A. Chadd and R.N. Baines, 2007a. Key health and welfare indicators for broiler production. World's Poult. Sci. J., 63: 46-62.

Manning, L., S.A. Chadd and R.N. Baines, 2007b. Water consumption in broiler chicken: A welfare indicator. World's Poult. Sci. J., 63: 63-71.

Marks, H.L. and T. Brody, 1984. Intakes of feed and water following restriction in selected and nonselected broilers. Poult. Sci., 63: 2307-2317.

Martin-Kleiner, I., Z. Flegar-Mestric, R. Zadro, D. Breljak and S.S. Janda *et al.*, 2001. The effect of the zeolite clinoptilolite on serum chemistry and haematopoiesis in mice. Food Chem. Toxicol., 39: 717-727.

Miles, R.D., R.H. Harms and S.M. Lourent, 1986. Influence of sodium zeolite A (Ethacal) on laying hen performance. Nutr. Rep. Int., 34: 1097-1103.

Min, B.S., Y.I., Kim, and S.J. Oh, 1988. Effects of zeolite levels on the performance of broilers. Korean J. Poult. Sci., 15: 31-38.

Minitab, 2000. Minitab Statistical Software Use's Guide 2: Data Analysis and Quality Tools. Minitab Inc., State College, PA., USA.

Moghaddam, H.N., M. Rezaei and A.H. Abadi, 2005. Effect of natural zeolite on performance and tibia composition of broiler chicks. Proceedings of the 17th European Symposium on the Quality of Poultry Meat and 11th European Symposium on the Quality of Eggs and Egg Products, May 23-26, Golden Tulip Parkhotel Doorwerth, Doorwerth, Netherlands, pp: 361-361.

Mumpton, F.A. and P.H. Fishman, 1977. The application of natural zeolite in animal science and aquaculture. J. Anim. Sci., 45: 1188-1203.

Mumpton, F.A., 1984. Use of Natural Zeolites in Agriculture and Aquaculture. In: Zeo-Agriculture, Pond, W.G. and F.A. Mumpton (Eds.). Westview Press, Boulder, Colorado, pp: 33-34.

NRC, 1994. Nutrient Requirements of Poultry. 9th Edn., National Research Council, Washington, DC., USA., ISBN-13: 9780309048927, Pages 155.

Nakaue, H.S. and U.K. Koelliker, 1981. Studies with clinoptilolite in poultry. I. Effect of feeding varying levels of clinoptilolite (Zeolite) to dwarf single comb white Leghorn pullets and ammonia production. Poult. Sci., 60: 944-949.

Nestorov, N., B. Yankov and V.N. Lazarov, 1985. Effect of the amount of zeolite in diets with urea on the digestibility of nutrients and nitrogen balance in fattening young bulls. Nutr. Abstr. Rev., 55: 389-389.

Ng'ambi, J.W., S.M. Maoba, D. Norris, M.S. Malatje and C.A. Mbajiorgu, 2009. Effect of dietary lysine to crude protein ratio on performance of male Ross 308 broiler chickens. Trop. Anim. Health Prod., 41: 11-16.

Nikolova, N. and Z. Pavlovski, 2009. Major carcass parts of broiler chicken from different genotype, sex, age and nutrition system. Biotechnol. Anim. Husbandry, 25: 1045-1054.

Oliver, M.D., 1997. Effect of feeding clinoptilolite (zeolite) on the performances of three strain of laying hens. Br. Poult. Sci., 38: 220-223.

Olver, M.D., 1989. Effect of feeding clinoptilolite (zeolite) to three strains of laying hens. Br. Poult. Sci., 30: 115-121.

Onagi, T., 1965. Evaluation of treatment of chicken droppings with zeolite-tuff powder. Report of Yanagala Stock Raising Institute, pp: 11-22.

Ozturk, E., M. Sarica and N. Karacay, 1996. The effects of adding natural zeolite (clinoptilolite) to broiler diets on fattening performance and carcass characteristics. Proceedings of the 4th National Nuclear Agric. Anim. Congress, (NNAAC'96), Uludag University Bursa, Turkey, pp: 39-45.

Papaioannou, D., P.D. Katsoulos, N. Panousis and H. Karatzias, 2005. The role of natural and synthetic zeolites as feed additives on the prevention and/or the treatment of certain farm animal diseases: A review. Micropor. Mesopor. Mater., 84: 161-170.

Papaioannou, D.S., C.S. Kyriakis, C. Alexopoulos, E.D. Tzika, Z.S. Pilizopoulou and S.C. Kyriakis, 2004. A field study on the effect of dietary use of a clinoptilolite-rich tuff, alone or in combination with certain antimicrobials, on the health status and performance of weaned, growing and finishing pigs. Res. Vet. Sci., 76: 19-29.

Pasteiner, S., 1998. Mycotoxins in Animal Husbandry. Biomin Gesunde Tierernahrung International GesmbH, Wien, Austria.

Prvulovic, D., D. Kojic, G.G. Lajsic and S. Kosarcic, 2008. The effects of dietary inclusion of hydrated aluminosilicate on performance and biochemical parameters of broiler chickens. Turk. J. Vet. Anim. Sci., 32: 183-189.

Quarles, C.L., 1985. Zeolits A new ingredient may cut needed to produce poultry red meal. Feedstuffs, 7: 35-36.

Rezaei, M., H.N. Moghaddam, J.P. Reza and H. Kermanshahi, 2004. The effects of dietary protein and lysine levels on broiler performance, carcass characteristics and N excretion. Int. J. Poult. Sci., 3: 148-152.

Roland, D.A., 1990. Further studies of effects of phosphorus and aluminosilicates on egg shell quality. Poult. Sci., 67: 577-584.

Roland, S.D.A., S.M. Laurent and H.D. Orloff, 1985. Shell quality as influenced by zeolite with high ion-exchange capability. Poult. Sci., 64: 1177-1187.

Safaeikatouli, M., F. Boldaji, B. Dastar and S. Hassani, 2010. Effect of different levels of kaolin, bentonite and zeolite on broilers performance. J. Biol. Sci., 10: 58-62.

Scott, M.L., M.C. Nesheim and R.J. Young, 1982. Nutrition of the Chicken. 3rd Edn., M.L. Scott and Associates Ithaca, New York, USA., ISBN-10: 0960272623, pp: 562.

Shariatmadari, F., 2008. The application of zeolite in poultry production. World's Poult. Sci., 64: 76-84.

Siegel, P.B., 1984. Factors influencing excessive fat deposition in meat poltry. Proceedings of the 17th World's Poultry Congress, (WPC'84), Helsinki, Finland, pp: 51-52.

Sykes, A.H., 1983. Food Intake and its Control. In: Physiology and Biochemistry of Domestic Fowl. Freeman, B.M. (Ed.). Academic Press, New York, pp: 1-29.

TSE, 1987. Carcass Slaughtering Rules. Turkish Standarts Institute (TSE) Publications, Ankara.

Tsitsishvili, G.V., T.G. Andronikashvili, G.N. Kirov and L.D. Flizova, 1992. Natural Zeolites. Ellis Horwood, Chichester, Sussex, UK Pages: 295.

Turkoglu, M. and M. Sarica, 2009. Poultry Science Breeding and Diseases. Bey Ofset Press, Ankara, Turkey, Pages 588.

Vest, L. and J. Shutze, 1984. Influence of Feeding Zeolite to Poultry Under Field Conditions. In: Zeo Agriculture: Use of Natural Zeolites. Pond, W.G. and F.A. Mumpton (Eds.). Westview Press, Boulder, Colorado, USA.

Watkins, S.E., C.A. Fritts, F. Yan, M.L. Wilson and P.W. Waldroup, 2005. The interaction of sodium chloride levels in poultry drinking water and the diet of broiler chickens. J. Appl. Poult. Res., 14: 55-59.

Wihandoyo, W., T.H. Wahyuni and A. Alimon, 2001. The effect of utilization bentonite and zeolite in the broiler diets on performance and fecal characteristics. Anim. Prod., 3: 1-4.

Willis, W.L., C.L. Quarles, D.J. Fagenberg and J.V. Shutze, 1982. Evaluation of zeolites fed to male broiler chickens. Poult. Sci., 61: 438-442.

Yalcin, H., 1997. Central North Anatolian zeolite occurrences related to Eocene submarine volcanism in Turkey. Bull. Eng. Fac. Cumhuriyet Univ. Serie A-Earth Sci., 14: 43-56.

Zainuddin, D., 1995. The effect of zeolite on performance of japanese quails in the tropical climate. Bull. Anim. Sci., 1995: 165-169.

Zimmermann, N.G., C.L. Wyatt and A.S. Dhillon, 1991. Research note: Effect of electronic treatment of drinking water on growth performance of broiler chickens. Poult. Sci., 70: 2002-2005.