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Effects of Housing Systems on Some Mineral Contents of Hen's Eggs

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This study was conducted to determine the effects of housing systems on the mineral contents and shell colour of eggs. Egg samples were collected from deep litter, cage, farmyard and traditional village production systems. Egg shell colour scale in farmyard, deep litter and cage systems were found darker than traditional village system ($p < 0.01$). Mn contents in village eggs were found significantly higher than farmyard, deep litter and cage systems eggs ($p < 0.05$). However, Fe and Zn minerals in deep litter system were higher than cage, farmyard and village systems eggs ($p < 0.01$). Although Cu contents in deep litter system eggs were higher than cage, farm and village system eggs, Na and K contents were significantly lower. There were no important difference among the Ca and Mg contents ($p > 0.05$) among housing systems. There were an important relationship between egg weight and the egg shell colour ($p < 0.01$), there was not significant relationship between the mineral contents and the shell colour ($p > 0.05$). As a conclusion, it can be said that the eggs of the deep litter system were the higher quality, when the egg shell colour and the mineral elements consider together.

Key Words: Housing systems, Cage, Village, Egg mineral contents, Laying hen, Atomic absorption spectrophotometer.

INTRODUCTION

Egg is very important food in human nutrition with respect to protein source. Different housing systems in egg production, such as farmyard, free-range, fold units, semi-intensive, straw yard, deep litter and cage have been used since years[1]. But, especially until 1950, only free range or semi-intensive housing system was applied. Egg production with these systems could not cover human needs due to rapidly increases of the world population. Therefore, the traditional cage systems with the higher stocking rate and the higher egg production per m^2 have been developed.

In 1990s, consumers demand more natural egg productions due to welfare and education levels, environmental care and animal rights, animal fertilizers which contain heavy metals[2] and some antibiotics having

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cancer risk[3,4]. Hence, alternative housing systems such as farmyard, free-range, straw yard, modified cage, aviary and perchery have become important around the world[5,6].

Some egg compounds such as fatty acids, vitamins, minerals, heavy metal contents etc. can affect significantly different housing systems. Vitamins E and A, omega-3 fatty acids and linoleik acid in eggs of free range systems have been found higher than eggs of cage systems[7-9]. In addition, heavy metal contents in eggs of the free range have been determined more than eggs of cage and deep systems[10,11]. Some researchers have suggested that the higher heavy metal contents in eggs come from environmental pollutants[12,13]. Although some studies have been done for egg fatty acids and vitamin contents for alternative housing systems, there are a few studies deal with egg's mineral element contents[11,14,15].

The aim of this study was to determine some metal contents in hen eggs and investigate the differences among egg production systems which are farmyard, deep litter, cage and village hens on mineral contents of eggs.

EXPERIMENTAL

Hen samples were grown in farmyard, deep litter and cage system at Hen Farm, Agricultural Faculty, Gaziosmanpasa University as four replicates. Eight eggs from 43-week old hens which have brown egg (GxSx) collected from each housing systems, in addition to village systems in Tokat Province. Total 32 egg samples were taken. Hens in farmyard, deep litter and cage housing systems were fed by *ad-libitum* laying rations (18 % CP, 2700 ME kcal/kg) and village hens by traditional village feed (barley, wheat, maize and pasture).

Egg samples were weighed. After determining shell colours (Minolta) shell colour scales were calculated from L-a-b (L: light or shine; a: redness; b: greenness) values[16].

All reagents used in this study were analytical reagent grade unless stated otherwise. Double deionised water (18.2 M Ωcm^{-1} resistivity) was used an aquaMAX^{TM}-*Ultra* water purification system (Young Lin Inst.) for all dilutions. H_2SO_4, HNO_3 and H_2O_2 were of suprapur quality (E. Merck). All the plastic and glassware were cleaned by soaking in dilute nitric acid (1+9) and were rinsed with distilled water prior to use. The standard solutions of metal ions for calibration procedure were produced by diluting a stock solution of 1000 mg/L of the all the investigated element supplied by Sigma and Aldrich.

Mineral and heavy metal contents of eggs were analysed using Perkin Elmer A Analyst 700 model AAS with deuterium background corrector and summarized in Table-1. All measurements were carried out in an air/acetylene flame. The operating parameters for studying elements (K, Na, Mg, Ca, Fe, Mn, Zn and Cu) were set as recommended by the manufacturer. Milestone Ethos D closed vessel microwave system (maximum pressure 1450 psi, maximum temperature 300°C) was used. Teflon reaction vessels were used for all the digestion procedures. The reaction vessels were cleaned using 5 mL of concentrated nitric acid before each digestion.

Egg samples were mixed up and *ca.* 2 g of samples were weighed in a Teflon vessel. The mixture of HNO_3: H_2O_2 (6:2) was added into the vessel. Then, the microwave digestion programs were applied to the samples. Digestion conditions for microwave system were applied as 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, Vent: 8 min, respectively. After digestion completed, the samples were diluted to 15 mL with distilled water. The metal determinations were performed by a flame atomic absorption spectrometry. A blank digest was carried out in the same way for each digestion. All sample solutions were clear. The levels of the analytes in the blank solution were close to the detection limit of the method.

The obtained values were analyzed on SPSS 10.0 Packet Program according to General Linear Model. Differences in the mean values were determined using Duncan multiple comparison test. The differences in the correlation coefficients of properties were determined and significance tests were done[17,18].

RESULTS AND DISCUSSION

The concentrations of the eight mineral elements in eggs are presented in Table-1 and correlations between egg shell colour and egg mineral contents are given in Table-2.

The brightness of egg shell colours (L) changed from dark to light in the order of village, farm yard, deep litter and cage system respectively ($p < 0.01$). The brightness of egg shell colour in the village egg was significantly ($p < 0.01$) higher than the other systems, regarding shell colour (redness and greenness) were significantly lower than other systems ($p < 0.01$). When egg shell scale (L-a-b) is taken into consideration, village egg values were higher than the others ($p < 0.01$).

The highest Mn concentration were obtained in the village eggs, while the lowest Mn concentration in the farm yard eggs and average concentrations were determined in the deep litter and cage eggs. Therefore, housing systems were important on Mn contents of eggs ($p < 0.05$). Fe contents in the deep litter eggs were much higher than the farmyard, cage and village eggs ($p < 0.01$). Cu mineral contents varied from the highest to the lowest as being the highest in the deep litter eggs and the lowest in the farmyard

TABLE-1
EGG SHELL COLOURS AND SOME MINERAL CONTENTS (mg/g) IN EGGS AT DIFFERENT HOUSING SYSTEMS

Housing system	Egg shell colour				Contents of egg mineral							
	L	a	b	L-a-b	Mn	Fe	Cu	Zn	Na	K	Ca	Mg
Deep litter	66.09^{a}	13.13^{a}	28.53^{a}	24.43^{a}	0.2343^{ab}	32.40^{a}	0.94^{b}	17.50^{a}	1870.43^{a}	8798.29^{a}	1127.00	262.86
Cage	65.06^{a}	12.77^{a}	27.61^{a}	24.68^{a}	0.1817^{ab}	19.62^{b}	0.73^{ab}	12.10^{b}	2702.50^{ab}	14381.80^{ab}	788.84	181.50
Farm yard	66.10^{a}	13.47^{a}	28.58^{a}	24.05^{a}	0.1338^{a}	18.86^{b}	0.57^{a}	10.97^{b}	3279.13^{b}	18832.10^{b}	860.63	236.86
Village	80.92^{b}	3.52^{b}	18.83^{b}	58.56^{b}	0.2800^{b}	22.64^{b}	0.81^{ab}	11.73^{b}	3828.25^{b}	22054.40^{b}	1076.88	309.38
SEM	1.325	0.808	0.875	2.944	0.0200	1.232	0.043	0.541	219.969	1712.400	60.268	16.661
P	< 0.00	< 0.00	< 0.00	< 0.00	< 0.032	< 0.00	< 0.018	< 0.00	< 0.015	< 0.041	< 0.191	< 0.093

The same letter in each column indicates no differences, statistically.

TABLE-2
CORRELATION BETWEEN EGG SHELL COLOUR AND EGG MINERAL CONTENTS

	Egg weight	L	a	b	Lab	Shell thickens	Mn	Fe	Cu	Zn	N	K	Ca	
Egg weight	1													
L	-0.798^{xx}	1												
a	0.822^{xx}	-0.976^{xx}	1											
b	0.793^{xx}	-0.901^{xx}	0.929^{xx}	1										
Lab	-0.820^{xx}	-0.986^{xx}	-0.990^{xx}	-0.958^{xx}	1									
Shell thickness	-0.069	-0.076	0.063	0.132	-0.090	1								
Mn	-0.395^{x}	0.266	-0.304	-0.235	0.273	0.317	1							
Fe	-0.046	0.023	0.029	-0.015	0.007	0.237	0.447^{x}	1						
Cu	-0.259	0.150	-0.132	-0.175	0.156	0.138	0.549^{x}	0.710^{xx}	1					
Zn	0.064	-0.142	0.169	0.119	-0.145	0.107	0.368^{x}	0.914^{xx}	0.628^{xx}	1				
Na	-0.112	0.175	-0.239	-0.107	0.176	0.134	-0.059	-0.494^{xx}	-0.318	-0.560^{xx}	1			
K	-0.171	0.075	-0.141	-0.050	0.087	0.395^{x}	-0.082	-0.305	-0.168	-0.447^{xx}	0.664^{xx}	1		
Ca	-0.171	0.097	-0.062	0.049	0.046	0.215	0.300	0.381^{x}	0.437^{x}	0.293	0.200	0.225	1	
Mg	-0.223	0.317	-0.288	-0.119	0.257	0.020	0.114	0.076	-0.017	-0.018	0.334	0.216	0.732^{xx}	1

x: $p < 0.05$; xx: $p < 0.01$

eggs. The average values were in the cage and village eggs. Mn and Cu contents of eggs were found important statistically for the housing systems ($p < 0.05$). Zn contents in the deep litter eggs were found higher than the farm yard, cage and village eggs ($p < 0.01$). Na content was the highest in the farmyard and village eggs and the lowest in the deep litter eggs ($p < 0.05$).

K contents were also significant in the housing systems ($p < 0.05$). The lowest in the deep litter, the highest in the farmyard and village eggs and the average values in the cage eggs were observed. However, the housing systems did not have significant effect on Mg and Ca contents.

The correlation coefficient between eggs weight and egg shell colour shine (L), redness (a), greenness (b), shell colour scale (L-a-b) and Mn contents were -0.798 ($p < 0.01$), 0.822 ($p < 0.01$), 0.793 ($p < 0.01$), -0.820 ($p < 0.01$) and -0.395 ($p < 0.05$), respectively and the relationship between same characters were found significant (Table-2). The correlation between L, a, b and L-a-b were calculated as -0.976, -0.901 and -0.986, respectively and the relation between them were found significant ($p < 0.01$). There was found an important relationship between shell colour redness (a) with shell colour greenness (b) and shell colour scale (L-a-b) ($p < 0.01$) as 0.929 and -0.990, respectively. The negative correlation (-0.958) between shell colour greenness and shell colour scale were found ($p < 0.01$). The important relation (0.395) were determined between shell thickness and K contents ($p < 0.05$). Also, the positive relation ($p < 0.05$) was found among Mn and Fe, Cu and Zn as 0.447, 0.549 and 0.368, respectively. The other correlation was calculated between Fe contents with Cu, Zn, Na and Ca 0.710 ($p < 0.01$), 0.914 ($p < 0.01$), -0.494 ($p < 0.01$) and 0.381 ($p < 0.05$), respectively. A relation was obtained among the Cu, Zn and Ca contents of the eggs as 0.628 ($p < 0.01$) and 0.437 ($p < 0.05$). The significant correlations were calculated among Zn and Ca and Mg as -0.560 and -0.168, similarly Na and K as 0.664 and Ca and Mg as 0.732 ($p < 0.01$).

While L-a-b values are smaller, egg shell colour getting darker[16]. According to Schwaegele[19] egg shell colour related with hen health, genetic structure and hen ages. Flock *et al.*[16] put forward there is no significant relation between shell colour and feed content. However, consumers prefer the darker shell coloured eggs. It can be said that consumers prefer eggs produced in farmyard, deep litter and cage systems over village system.

Contents of some minerals (Cu, Zn, Mg, Ca and Fe) in the eggs were higher in the village system than the cage system[15]. In contrast, the mineral contents in the cage system's eggs were higher than the others, except Mn and Na[14,20]. The results of this work are in agreement with the literature[14,20]. There were no important relations among properties shell colour and minerals in this investigation. This results are similar to Flock *et al*[16].

Conclusions

It could be concluded that while the darkest shell colour of egg was obtained in cage system, the lightest egg was obtained in village systems. In terms of the Mg, Na and K content village system has advantage than the other systems. Fe, Cu and Zn in the deep litter system were higher than others. When egg shell colour and mineral contents are considered together, it can be suggested that the egg production of the deep litter system was to be higher quality.

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