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Effects of Different Housing Systems on Some Performance Traits and Egg Qualities of Laying Hens

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Abstract: This research was carried out to investigate the effects of husbandry systems (deep litter, free range and cage systems) on brown layer strain of ATAK (G_xS_x) in terms of egg production and egg quality. In the experiment, deep litter and free range systems were replicated four times with 20 birds per replication and the cage system was replicated six times with 16 birds per replicate. Water and feed were supplied *ad libitum* to the birds in the experiment. In deep litter, free range and cage systems, respectively: 50% production age was 168.75, 160.00 and 158.33 days (p>0.05); feed intake (g/bird/day) was 157.21, 146.70 and 134.33 (p<0.01); bird weights at 5% egg yield were 1732.07, 1697.27 and 1775.05 g (p<0.01); hen housed egg production was 96.44, 118.08 and 111.00 eggs (p>0.05); egg shape index was 76.46, 76.05 and 77.27% (p<0.01); egg shell colour (L-a-b) was 25.28, 23.80 and 22.56 (p<0.05); egg albumen pH values were 8.79, 8.72 and 8.72 (p<0.01); cracked egg ratio was 2.66, 2.02 and 3.13% (p>0.05). The free-range system had some advantages when compared to deep litter and cage systems in terms of 5% yield age weight, hen housed egg yield, egg shape index and cracked egg ratio. However, as a result of the study, it has been determined that there were no great differences among deep litter, free-range and cage systems. More detailed studies are necessary to show the differences and advantages of the main poultry housing systems.

Key words: Housing systems, deep litter, free range, cage, egg quality, birds

INTRODUCTION

In recent years, there has been a rapid improvement in poultry husbandry. As a result of improvements in the management, disease control, nutrition, genetics of layers, in addition to advances in technology, egg quality and composition have undoubtly changed. The vast majority of the world's populations of laying hens are housed in cages (Abrahamsson, 1996; Sorensen *et al*., 2006). Housing systems for poultry have already been widely discussed (Mostert *et al*., 1995). It is apparent that every system has advantages and disadvantages in relation to animal health and welfare and performance. The cage system of housing laying hens is the most economical and limits sanitary problems. However, although the productivity and health of birds are better than in other systems, there are serious welfare disadvantages in the cage systems (Elson, 1992; Petek, 2004). The lack of freedom of movement, comfort, shelter, suitable flooring and freedom to display most normal patterns of behavior has aroused many discussions about poultry welfare. As a result of these endeavors and new legislation for higher welfare egg production systems (Kuit *et al*., 1989; FAWC, 1997), several alternative systems have been proposed and increasingly practiced in the past two decades. Such as deep litter, perchery, aviary, free range and enriched cages systems. These alternative housing systems accommodate for most of the welfare concerns that are found in battery cage housing systems. They provide physical space and greater environmental complexity including litter, perches, dust-bathing, pecking, scratching behaviors and egg laying facilities (Elson, 1992; Petek,

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2004). Scientists have made various conflicting reports about the contamination of eggs under different housing systems. Garber *et al.* (2003) reported that birds reared under deep litter floor systems had higher risk of infection with Salmonella compared to those kept under cage systems. In contrast, Namata *et al.* (2008) and Methner *et al.* (2006) reported a higher risk of contamination under cage systems. On the one hand the farm and flock sizes are significantly higher in cage farms than deep litter floor systems that might lead to a higher probability of within farm diffusion in the case of introduction compared to deep litter floor systems. Conversely, cage poultry-houses are difficult to clean and disinfect (Valancony *et al.*, 2001) and Salmonella contamination has been shown to be more persistent in successive flocks housed in cages than on-floor due to poor standards of cleaning and disinfection in cage farms (Davies and Breslin, 2001).

Not with standing that most of the research on the effects of housing systems on egg production have been carried out in other countries, while very limited research conducted in Turkey (Sekeroglu, 2002; Sarica *et al.*, 2004; Sekeroglu and Sarica, 2004). This research, Comparing conventional cage housing system and the deep litter floor system to free range systems in Turkey may provide new insights in general to housing systems of laying hen in Turkish. The objective of this study was to determine the effects of three different housing systems (deep litter, free range and cage) on egg production performance and egg quality of laying hens.

MATERIALS AND METHODS

This experiment was conducted at College Farm, Gaziosmanpasa University, Turkey. The birds used in this experiment consisted of 10 weeks old hybrid of ATAK (G_xS_x) brown layer strain which were obtained from Sinop Poultry Production Station, Ministry of Agriculture and Rural Affairs, Turkey. All the birds were previously reared on a deep litter system until 10 weeks of age. A total of 256 birds of similar weights were chosen and reared on deep floor pens for a further 2 weeks.

At the beginning of week 13, birds were individually weighed and randomly distributed into three experimental groups. Four replicates of 20 birds per replication (a total of 80 birds) were used for the deep litter floor system treatment. About 8-10 cm of wood shaving was used as bedding. An identical number of replications (4) and number of birds (80) were used for the free range system treatment. However, the cage system treatment was replicated six times. Four cages with four bids in each were used for each one of the six replicates (96 birds and 24 cages in total).

The stocking density in the deep litter system was 3.7 bird m^{-2}. In the free range system it was 1.0 bird m^{-2} with additional access to outdoor areas. Twenty four standard cages of (48×42×45 cm size) were used with a stocking rate of 4 birds per cage.

Water and feed were provided *ad libitum* and birds in all 3 treatments were allocated with equal space of feeders and drinkers.

Laying nest boxes (35×35×35 cm size each) with wood shaving bedding were used at a rate of 2.5 hens per box. The daily photoperiod consisted of 16 h of light and 8 h of darkness. The lighting intensity was 3.0 watt m^{-2}. During the experimental period birds in the free range system treatment had access to outdoor range during the day light (08.00 am-17.00 pm).

Birds were fed with a pullet grower diet containing 2850 kcal ME kg^{-1} and 15% crude protein until 20 weeks of age. Between week 21 and 43, the standard layer diet was supplied (2700 kcal ME kg^{-1} and 18% crude protein) (NRC, 1994).

During the experimental period, daily egg production traits recorded were: egg yield (egg/hen/day); age (day) at 5 and 50% egg production; live weights at 5 and 50% egg production age and live weights at the end of the experiment.

The average egg weight (g) was calculated from the number of hen-day eggs and total weight. The average daily feed consumption per bird was calculated from total hen-day feed consumption. Hen-Day Egg number (HDE) and Hen-Housed Egg number (HHE) were calculated using the following formula:

$$\text{HDE} = \left(\frac{\text{No. of eggs produced during period}}{\text{No. of hen day in the period}}\right) \times \text{days}$$

$$\text{HHE} = \left(\frac{\text{No. of eggs produced during period}}{\text{No. of hens present at 21 weeks}}\right)$$

In order to determine egg quality characteristics, 20% of the eggs produced weekly (weeks 26-33) were selected randomly and kept at room temperature for 24 h and then taken for quality measurements. The following physical properties of egg samples were determined: linear size dimensions, Length (L) and Width (W). These were measured with a digital caliper to the nearest 0.01 mm.

The length and width of eggs was determined by egg shape measurer and their Shape Index (SI) was determined according to Anderson *et al.* (2004).

$$\text{SI} = \left(\frac{\text{W}}{\text{L}}\right) \times 100$$

The Egg Weight (EW) was measured with an electronic balance to the nearest 0.001 g. Egg shell colour was measured using a Colorimeter 300B (Nippon Denshoku, Tokyo, Japan) (Flock *et al*., 2001).

Shell thickness was measured according to Chawdhury[19]. Breaking strength (rupture force) was measured by the data acquisition system using Zwick/Roell (Instruction Manual for Materials Testing Machines/BDO-FB 0.5 TS). The egg samples were placed on a moving platform with a loading position of 0.66 mm sec^{-1} compression speed and pressed with a plate fixed on the load cell until the egg ruptured at x-axis (Altunta and Yildiz, 2007). The x-axis is the longitudinal axis through the hilum (length).

Albumen and yolk height were measured using a sperometer. The yolk and albumen length were measured by electronic slide callipers. Yolk colour was measured using DSM Yolk Colour Fan. Individual Haugh Unit (HU) score was calculated using the egg weight and albumen height (Haugh, 1937). The Haugh Unit values were calculated for individual eggs using the following formula:

$$HU = 100 \log_{10}(H - 1.7\,W^{0.37} + 7.57)$$

Where:

H = Observed height of the albumen in mm

W = Weight of egg in grams

Albumen Index (AI) is related to the Albumen Height (AH), Albumen Length (AL) and Albumen Width (AW) and calculated with the following formula (Doyon *et al*., 1986):

$$AI = \left(\frac{AH}{(AL+AW)/2}\right)\times 100$$

Yolk Index (YI) is related to the Yolk Height (YH) and Yolk Width (YW) and calculated with the following formula (Doyon *et al*., 1986):

$$YI = \left(\frac{YH}{YW}\right)\times 100$$

Meat-blood spotted egg ratio of the eggs was calculated and pH of the egg albumen was determined using a manually operated pH meter (Model 3310, 545 007/REV A/03-96).

Egg production and Egg quality parameter data were subjected to statistical analysis by the Generalized Linear Model Procedure of SPSS (SPSS 11.0).

The data distribution was tested for normality by probit analysis and variance homogeneity by Bartlett test. The significant differences between the mean values of the three different systems were determined by one-way variance analyses and Duncan tests in terms of livability, live weight, feed consumption, egg yields, egg weight and egg quality characteristics.

RESULTS AND DISCUSSION

All hens in the 3 housing systems reached the 5% production age within approximately 148-149 days of age and there was no statistical difference between the housing groups ($p>0.05$). Results obtained from the study are shown in Table 1.

Live weights at 5% yield age for birds housed in the free range system were significantly lighter than those kept in the cage system ($p<0.001$). The effect of housing systems on live weight at 50% yield age ($p<0.01$) and live weight at the end of the experiment (weeks 43) was found to be insignificant ($p>0.05$). The cage system reared laying hen consumed lower feed than from other systems ($p<0.001$). Mean weights of eggs were defined according to housing systems and presented as 64.44 g for cage, 60.91 g for deep litter and 59.93 g for free range (Table 1). There was no significant difference in egg weights according to housing systems ($p>0.05$).

Egg quality characteristics of brown laying hen (ATAK) hybrid breed in deep litter, free range and cage systems were shown in Table 2. Egg shape index in deep litter and free range housing systems eggs was significantly lower than that of cage housing systems ($p<0.001$). The Lightness (L) of eggshell colours changed from light to dark in the order of deep litter (66.19), free range (65.47) and cage egg (64.38), respectively ($p<0.001$). Shell colour scales (L-a-b) changed from light to dark in the order of deep litter (25.28), free range (23.80) and cage systems egg (22.56), respectively ($p<0.05$). Egg pH of the deep litter housing system was significantly higher than those of egg pH from free range and cage systems ($p<0.001$). There were no statistical differences between the housing systems in terms of albumen index ($p>0.05$) and Haugh unit ($p>0.05$).

This study provided an opportunity to study hen performance as well as egg traits. Hens kept in the cage system reached sexual maturity (50% yield age) two days before those in the free range system and 10 days before the birds in the deep litter system. Whilst these results are in agreement with Sekeroglu (2002) and Petek (2004), they stated that the effect of housing system was not significant on sexual maturity age in contrast to Keeling and Dun (1988) who have indicated that the effect of housing systems on sexual maturity age was important (free range systems 135 days and cage systems 168 days).

Many researchers have reported that the effects of housing systems on egg yields were not significant and egg production of animals that were kept in free range system were lower (Hughes and Dun, 1982; Folsch *et al.* 1988; Pavlovski *et al.* 1992; Mostert *et al*., 1995). Results

Table 1: Performance traits of brown laying hen (ATAK) hybrid breed in deep litter, free range and cage systems

	Housing systems				
Traits	Deep litter	Free range	Cage	SEM*	P**
5% yield age (day)	148.75	148.50	148.50	0.39	0.97
50% yield age (day)	168.75	160.00	158.33	1.98	0.07
Initial body weight (g)	956.44	959.56	957.47	5.22	0.97
5% yield age weight (g)	1732.07^{ab}	1697.27^{b}	1775.05^{a}	10.64	0.00
50% yield age weight (g)	1855.75	1793.29	1836.72	10.92	0.07
Weight in week 43 (g)	2163.09	2160.95	2141.48	15.23	0.80
Egg yield (Week 43)					
Hen-day egg number (Eggs/bird)	114.39	126.86	116.64	3.53	0.38
Hen-housed egg number (Eggs/bird)	96.44	118.08	111.00	4.72	0.22
Feed intake (g/bird/day)	157.21^{c}	146.70^{b}	134.33^{a}	3.14	0.00
Egg weight (g)	60.91	59.93	66.44	2.13	0.40

*Standard Error of the Means, **Difference among features that are shown in the same line by different letters is statistically important = $^{a-b}$: Means within rows with different superscripts differ at $p<0.05$ or $p<0.01$

Table 2: Egg quality characteristics of brown laying hen (ATAK) hybrid breed in deep litter, free range and cage systems

	Housing systems				
Traits	Deep litter	Free range	Cage	SEM*	P**
Shape index (%)	76.460^{a}	76.050^{a}	77.270^{b}	0.16	0.00
Egg shell thickness (mm)	0.360	0.360	0.360	0.13	0.79
Shell colour					
L	66.190^{a}	65.470^{a}	64.38^{b}	0.20	0.00
a	18.410	18.790	18.690	0.12	0.48
b	22.500	22.880	23.130	0.20	0.41
L-a-b	25.280^{b}	23.800^{ab}	22.560^{a}	0.46	0.04
Specific gravity (g cm^{-3})	1.091	1.092	1.091	0.00	0.33
Shell breaking force (kg cm^{-2})	2.290	2.370	2.370	0.04	0.68
pH	8.790^{a}	8.720^{b}	8.720^{b}	0.01	0.00
Albumen index (%)	11.430	11.080	10.810	0.28	0.66
Haugh unit	91.920	92.530	92.420	0.44	0.85
Yolk index (%)	44.010	44.010	43.920	0.12	0.93
Yolk colour, DSM	10.310	10.240	10.230	0.05	0.50
Meat-blood spotted egg ratio (%)	15.630	26.040	30.100	2.74	0.08
Cracked egg (%)	2.660	2.020	3.130	0.21	0.07

*Standard Error of the Means, **Difference among features that are shown in the same line by different letters is statistically important = $^{a-b}$: Means within rows with different superscripts differ at $p<0.05$ or $p<0.01$. DSM; DSM Yolk Color Fan

from the present study are closer to the outcomes of Keeling *et al.* (1988), Sekeroglu (2002) and Petek (2004), because they stated that hen-housed egg production of birds housed in free range system were highest.

Although, Hughes and Dun (1982), Purvis (1986) and Sencic *et al.* (2006) found that free range eggs were heavier than the other systems, the eggs from the free range system in this study were lighter than those from the cage and deep litter systems. This finding was also reported by many researchers (Keeling and Dun, 1988; Pavlovski *et al.*, 1992, 2004; Mostert *et al.*, 1995).

This study suggests that the effect of choice of housing system on feed consumption was important and more feed was consumed in free range systems than cage system (Hughes and Dun, 1982; Gibson and Dun, 1985; Purvis, 1986). Although, results of the present study agree with the above mentioned researchers in terms of the effect of housing systems on feed consumption, it differs on the ground that animals housed in free range system consumed more daily feed than those housed in deep litter system. Exact feed consumptions according to housing system in this study have been defined for deep litter, free range and cage systems as 157.21 g/bird/day, 146.70 and 134.33 g/bird/day, respectively.

The effect of housing systems on egg shape index was significant with a significantly greater index number in cage system than in other housing systems. Findings of the study is similar to Pavlovski *et al.* (1994, 2004) but different from Sekeroglu (2002) who indicated that the shape index of eggs from free range system was higher than from other systems.

Standards of eggshell colour index (L-a-b) in brown eggs vary between 19.2-26.4 (Flock *et al.*, 2001). Egg shell colour indices in this study were classified as 22.56, 23.80 and 25.28 in cage, free range and deep litter systems, respectively. All the determined values for egg shell colour indices in this study were in the standard range. Additionally, darker egg shell colour was found in eggs with lower yolk indices. Lightest coloured eggshell was obtained from the deep litter system but Pavlovski *et al.* (1994, 2004) detected the darkest coloured eggs hell from cage system while lightest egg shell colour was in free range system.

Although, there were no statistical differences between the housing systems in terms of albumen index and Haugh unit, albumen pH showed a significant variation among the housing systems with the highest albumen pH value being detected in deep litter system.

While Torges *et al.* (1974) reported that layers housed in cage system produce eggs with a darker yolk colour, many researchers indicated that layers housed in free range system give eggs with darker yellow (Dutta, 1993; Pavlovski *et al*., 1994, 2004) but in this study yolk colour was not statistically different between housing systems.

Although, the greater value was in deep litter floor system, this effect on meat-blood spotted egg ratio was not significant; this result is also in agreement with literature reports by Sauveur (1991) and Sekeroglu (2002).

CONCLUSION

As a result of the study, it has been determined that there was no great difference among deep litter, free-range and cage systems. However, some advantages of free range systems have been detected. Nevertheless it is a well known trend that some consumers prefer free range poultry products because they think that free range products are healthier than others. Therefore more detailed studies have to be carried out on free range poultry products to inform consumers. With the support of this kind of study controlled free range production may spread throughout the rural area.

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