IJAS Iranian Journal of Applied Animal Science

Evaluation of Two Laying Systems (Floor *vs*. Cage) on Egg Production, Quality and Safety

Research Article

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Received on: 22 Jul 2013
Revised on: 22 Oct 2013
Accepted on: 30 Oct 2013
Online Published on: Sep 2014

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Online version is available on: www.ijas.ir

ABSTRACT

A study was conducted to evaluate the effects of two laying systems (floor versus cage) on egg production, egg quality, and microbial safety. One hundred and eighty 42 wk old laying hens were separated into two groups of 90 hens each, and housed in laying cages and a floor laying system. Eggs from the hens were collected for 2 weeks, and hen-day egg production, egg quality (whole egg, albumen, yolk and shell weights), saleability, and marketability were measured. Total bacteria counts on the egg shell surface were also enumerated at 0, 4 and 8 h after laying. Results indicated that hen-day egg production by hens in the cage system (95%) was significantly (P<0.05) higher than production by hens from the floor system (85%), but there was no significant differences in egg weight, albumen, yolk, or shell weights. Hens housed in the cage laying systems produced significantly (P<0.05) more marketable eggs (95%) than hens housed in the floor laying system (89%). Significantly (P<0.05) more unsaleable eggs were also produced by hens in the floor laying system (11%) than in the cage system (4%). Bacteria counts on egg shells from hens of the cage laying system were significantly (P<0.05) lower at 0 and 4 h after laying (4.02 and 5.90 log cfu/mL, respectively) than counts on shells of eggs from the floor laying system (6.58 and 7.25 log cfu/mL, respectively). There was no significant difference in contamination of eggs collected 8 h after laying. Findings indicate hens housed in cages produce more eggs with higher quality and less bacterial contamination than hens house in floors laying systems.

KEY WORDS bacteria counts, egg production, laying systems.

INTRODUCTION

The sale of eggs like all other farm products is driven by consumer demand and perception. Many consumers currently believe cage-free, organically produced eggs have higher quality and are safer for consumption than eggs from hens housed in cage systems. There is also concern about the welfare of the birds that are housed in cage systems. Jones *et al.* (2004) reported that consumer concern has led to new challenges for poultry growers. *Salmonella enteritidis* have been identified as one of the major pathogens associated with raw and undercooked shell eggs and egg products. With the focus on food safety and the welfare of birds, alternative systems to the conventional system are being introduced (Protais *et al.* 2003; Mallet *et al.* 2004; De Reu *et al.* 2005). The demand for cage-free or organic eggs is creating a trend that is shifting towards free-range and floor-reared birds. De Reu *et al.* (2005) stated that the shift from conventional cage systems has increased the incidence of microbial contamination and reduced the quality of egg shells, especially eggs produced during warmer months. Ellen *et al.* (2000) reported that the concentration of dust accumulated in the floor housing system, contributes to higher contamination of eggs with bacteria compared to

hens raised in the cage systems. Also, Protais *et al.* (2003) and De Reu *et al.* (2005) reported higher egg shell contamination by mesophilic, aerobic bacteria in perchery system compared to conventional cages. High levels of external shell contamination can significantly affect shelf-life and safety of eggs (Hannah *et al.* 2011). De Buck *et al.* (2004) stated that bacterial contamination on egg shell can affect shelf-life when the bacteria attached on to the shell surface. According to Mollenhorst *et al.* (2005) cage system with wet manure increases the risk of contamination in contrast to cage system with dry manure, while Van den Brand *et al.* (2004) observed that egg shell quality decreases with age in cage birds compared to outdoor birds and suggested that egg shell thickness in relation to housing system could be used as a bio-indicator for the health and production of layers. Peebles *et al.* (2000) and Silversides and Scott (2001) and Pavlovski *et al.* (1991) indicated that the effect of age on yolk and albumen percentage and yolk-albumen ratio decreases with age in the cage layers with no variable differences in albumen height with increase age of the hen. The objective of the present study was to examine the difference in egg production and bacterial contamination of eggs from hens housed in conventional laying scage or in a floor laying system.

MATERIALS AND METHODS

One hundred and eighty 42 wk old Single Comb White Leghorn (SCWL) hens (Hy-line® W36) were selected at random from a larger flock of hens and assigned to two treatment groups in a complete random design. Ninety hens were placed in the cage laying system, 90 hens were placed in the floor laying system, and hens in each system were separated into groups of 30 to provide three replicates for each treatment. Two weeks prior to the start of the study, all hens were placed on diet formulated to closely match the recommendation of the NRC ((Table 1). Hens were provided feed and water at *ad libitum* and exposed to 16 h incandescent light/day, throughout the study.

The two laying systems (cage and floor) were located in the same building, separated by a small feed storage room with similar environmental temperature and relative air humidity. The conventional cages (640 cm^2) area consisted of two rows of two tiers, with each row containing 45 cages housing 90 hens, with 2 hens per cage. The commercial conventional cages measured 30.5 × 35.56 × 50.8 cm, the floor laying system was an area of 2708 sq ft that was covered with wood shavings. The laying area was divided into three identical pens of 90 sq ft in area. Each floor pen consisted of a single nest box to accommodate 30 hens in each pen and was equipped with a plastic feeder (16 inches in diameter) and an automatic plastic (plassum type) water drinker.

Data collection

Eggs were collected 3 times daily at 4 h intervals from each treatment group. Egg production, egg weight, and saleability were recorded daily. Eggs were collected and analyzed weekly for yolk, albumen and shell weights. Five eggs from each treatment group were separated from each daily production.

These eggs were cracked open with the aid of a spatula, and the yolk, albumen, and shell were separated and weighed individually. Egg weights were expressed as percent of the whole egg (relative weight).

Table 1 Composition of diet

Ingredient	Percentage
Yellow corn	55.93
Soybean meal (44% CP)	22.10
Alfalfa meal (17% CP)	5.00
Meat and bone meal (50% CP)	3.00
Animal and vegetable fat	3.00
Limestone	8.22
Di-calcium phosphate	1.15
Iodine salt	0.25
Vitamin trace mineral premix[1]	1.50
Calculated values	
Crude protein (%)	17.00
ME kcal/kg	2830
Crude fat (%)	4.00
Phosphorus (available) (%)	0.35
Calcium (%)	3.20
Methionine (%)	0.34
Methionine and cystine (%)	0.62
Lysine (%)	0.76

Vitamin premix per kg of diet: vitamin A (as vitamin A outtake): 12000 IU; cholicalcifrol (as-fed basis): 3000 IU; vitamin E (as x-tocopheryl acetate): 20 IU; vitamin B_{12}: 15 ug; Menadione sodium bisulfile: 2.0 mg; Thiamine: 1.5 mg; Riboflavin: 8.0 mg; Niacin: 3000 mg; Pantothinic acid: 150 mg; Pyridoxine: 40 mg; folic acid: 1.0 mg; Biotin: 150 ug; Cobalt: 2 mg; Copper: 10 mg; iron: 80 mg; Iodine: 1.0 mg; Manganese: 120 mg; Zinc: 120 mg; Selenium: .2 mg; Butylated hydroxybotuene (BHT): 150 mg and Zinc bacitracin: 20 mg.

Bacterial enumeration

Ten eggs from each 4 h collection period were placed into 400 ml of Butterfield buffer solution and stored for 24 h at 32 F, after which they were then placed in a Stomacher bag containing Butterfield stock solution and rubbed for 60 seconds as described by De Reu *et al.* (2005). One ml of the egg wash was serially diluted and the diluents were plated on tryptic soy nutrient agar, to examine the growth of microorganisms. The plates were incubated for 24 h at 36 °C, and colony-forming-units (cfu) were counted. The counts were transformed to logarithms for statistical analysis.

Data analysis

All data were analyzed by ANOVA, using the General Linear Models procedures of SAS® (SAS Institute, 2000). Significant differences among the two treatment means were determined using Duncan's multiple range test (1955) with a predetermined 5% probability level.

RESULTS AND DISCUSSION

Percent hen-day production, unsaleable, and marketable eggs for hens reared in conventional cages and on floor litter are presented in Table 2. There were significant differences (P<0.05) in egg production, unsaleable and marketable eggs between the two rearing systems when the data were analyzed using the ANOVA procedure. The result showed that hens reared in the conventional cage system had significantly (P<0.05) higher egg production (95%) compared to hens reared in the floor system (85%). There were significantly (P<0.05) higher percentage (11%) of unsalable eggs from hens reared on the floor system compared to the conventional cage system (4%). The percentage of marketable eggs (95%) was significantly (P<0.05) higher for hens placed in the conventional cage system than hens placed in the floor system (89%).

Table 2 Difference between conventional cage and floor laying systems on total egg production, saleable eggs and marketable eggs

Systems	Unsaleable[1] eggs (%)	Hen-day production (%)	Marketable[2] eggs (%)
age layers	4[b]	95[a]	95[a]
Floor layers	11[a]	85[b]	89[b]
SEM	3.94	10.61	6.16

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
[1] Saleable eggs are eggs considered broken, misshaped and cracked.
[2] Marketable eggs are the difference in hen-day production and unsaleable eggs.
SEM: standard error of the means.

Table 3 shows the results for egg weight, albumen, yolk and shell weights. There were no significant differences between the two rearing systems for any of the parameters measured. However, there were significant (P<0.05) differences in the bacteria load recovered from the shell of the eggs collected at the first collection (8, 00 am) and the second collection period (4:00 pm) (Table 4).

Table 3 The difference between conventional cage and floor laying systems on total egg, albumen, yolk and shell weights

Systems	Mean weight (g)			
	Egg	Albumen	Yolk	Shell
Cage layers	64[a]	39.4[a]	21.05[a]	8.89[a]
Floor layers	62[a]	38.29[a]	20.05[a]	9.27[a]
SEM	2.11	2.11	1.12	0.72

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
Mean egg weights were calculated over 14 day period.
Ten eggs from each treatment, at each period (n=10).
SEM: standard error of the means.

The total bacteria counts for eggs collected from the floor laying system at 8:00 am, (5.85×10^8 cfu/mL), were significantly (P<0.05) higher than the bacteria counts collected on eggs from the cage system(3.75×10^8 cfu/mL). Bacterial contamination of eggs collected during the second collection period from the egg shells in the floor system was significantly (P<0.05) higher (7.15×10^8 cfu/mL) than bacterial contamination (5.85×10^8 cfu/mL) of egg shells collected from the cage system. The bacterial count recovered from the eggs collected 4 h after laying in the floor system, was significantly (P<0.05) higher (7.15×10^8 cfu/mL) compared to those (5.85×10^8 cfu/mL) collected from egg shell from the cage system. No significant differences were observed in total bacteria counts on the egg shell between the two laying systems when the eggs were collected 8 h after laying. In the commercial egg production laying hens are managed at high densities. As a result, the environment in which the hens are raised is normally actively managed to encourage optimum productivity levels.

Table 4 The differences between cage and floor laying system on bacterial counts on eggs over three collection periods

Systems	Total bacteria[1] counts (cfu)		
	0[2]	4[2]	8[2]
Cage layers	4.02[b]	5.96[b]	7.25[a]
Floor layers	6.58[a]	7.25[a]	7.35[a]
SEM	1.89	0.96	0.05

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
[1]Total bacterial counts (log cfu/mL).
[2] Represents period of the days when eggs were collected.
SEM: standard error of the means.

The difference between the laying systems is that the cage system is better suited for large egg production. Therefore, better control of the environment, water and feed qualities, less fecal contamination of the eggs, with less unsaleable eggs are critical for economic success. Clean drinkers and feeders are not easily maintained to protect the hens from the impact of outside environment in the non-conventional system. Isolation of the hens from fecal material in floor operation is essential to provide clean eggs with less bacterial contamination.

Comparing the fecal contamination of eggs laid in different types of housing systems, Protais *et al.* (2003) and De Reu *et al.* (2005) found total bacterial counts of egg shells were higher in floor system compared with conventional cage system. The bacterial count of the current study on eggs collected from the floor system was 6.58 log cfu/mL compared to 4.02 log cfu/mL for the eggs from the cage system at the zero hour collection. A higher shell bacteria count on eggs from organic and free range farms been previously reported by De Reu *et al.* (2005). Guillam *et al.* (2007) reported higher dust contamination in perchery rearing systems compared to cage poultry houses. Radon *et al.* (2002) attributed the high bacteria load on floor system eggs to a high concentration of airborne bacteria. The difference in bacteria load observed in the current study between the two systems may have been associated with feces on the shell.

Tauson *et al.* (1999) in an earlier study reported a higher percentage of dirty eggs from floor hens than cage. Furthermore, floor eggs are likely to be damaged or spoiled and are far more easily contaminated (Protais *et al.* 2003)

and results of the current study indicated that there was a higher percentage of unsaleable and less marketable eggs due to cracks and breakages in eggs collected from the floor system. Interestingly, the differences between the two systems in bacteria count were minimal, not significant after 8 h of laying, suggesting that eggs should be collected before 4 h after laying to minimize the accumulation of bacteria on shell eggs since after 4 h the contamination of bacteria increases in each system.

Egg laying systems are designed for low production cost with a high degree of mechanism to increase production and egg quality (Fleming *et al.* 1994). Because of the low stocking density of free-range systems egg production is lower and is more expensive to produce and as such demand significant market premium to be competitive (Patterson *et al.* 2001).

Tauson *et al.* (1999) reported that egg production of laying hens was higher in conventional cage than those housed in alternative systems such as floor pens. Higher egg production may be due to greater efficiency in feed utilization, as the dietary energy is converted more efficiently to egg production due to the hen confinement. Conversely, hens in floor pens use more feed energy for exercising, scratching, and bathing in the litter.

CONCLUSION

The result shows that there are significant differences in total egg production, marketable egg production and eggs with lower microbial contamination between eggs from conventional cage systems and floor laying systems. Hen-day egg production is significantly higher for the cage system and with more marketable eggs allowing for lower egg cost. Eggs with less bacteria contamination are safer and have a longer shelf-life. An indication of an overall healthy environment for the birds is the condition of the litter in the floor system. Litter prevents the birds from directly contacting the floor, dilution of feces, resulting in the reduction of bacteria, toxins and parasites. Poorly managed litter in large floor houses reduces the ability of litter to dilute feces, creating an avenue for the birds to peck at the litter, increasing the intake of bacteria. High stocking density in floor systems impact litter quality, which will affect egg production, quality, and safety. Finally, to enhance food safety, the eggs should be collected at least 4 h after laying to minimize bacterial contamination.

ACKNOWLEDGEMENT

The authors wish to acknowledge the assistance of Cassandra Gray and Vivian Vaughan for the help they gave in the completion of the study, and the facilitations provided by the University.

REFERENCES

De Buck J., Van Immerseel F., Haesebrouck F. and Ducatelle R. (2004). Colonization of the chicken reproductive tract and egg contamination by *Salmonella*. *J. Appl. Microbio.* **97,** 233-245.

De Reu K., Grijspeerdt K., Heyndrickx M., Zoons M., Debevere J. and Herman L. (2005). Bacterial eggshell contamination in conventional cages, furnished cages and aviary housing system for laying hens. *Br. Poult. Sci.* **46,** 149-155.

Ellen H.H., Bottcher R.W., Von Wachenfelt E. and Takai H. (2000). Dust levels and control methods in poultry houses. *J. Agri. Saf. Health.* **6,** 275-282.

Fleming R.H., Whitehead C.C., Alvey D., Gregory N.G. and Wilkins I.J. (1994). Bone structure and breaking strength in laying hens housed in different husbandry systems. *Br. Poult. Sci.* **35,** 651-662.

Guillam M.T., Claude C., Dewitte J.D., Michael V. and Segala C. (2007). Health hazards and inhalatory exposures in poultry farming. *Br. Poult. Sci.* **51,** 163-169.

Hannah J.F., Wilson J.L., Cox N.A., Cason J.A., Bourassa D.V., Musgrove M.T., Richardson L.J., Rigsby L.L. and Buhr R.J. (2011). Comparison of shell bacteria from unwashed and washed table eggs harvested from caged laying hens and cage-free floor-housed laying hens. *Poult. Sci.* **90,** 1586-1593.

Jones D.R., Burtis P.A., Anderson K.E. and Jones F.T. (2004). Microbial contamination in inoculated shell egg, II. Effect of layer strain and egg storage. *Poult. Sci.* **83,** 95-100.

Mallet S., Guesdon V. and Nys Y. (2004). Hygienic properties of egg laid at different locations in two furnished cage models, Pp. 6 in Proc. 22th World's Poult. Cong. Instabul, Turkey.

Mollenhorst C., Van Woudenbergh C.J., Bokkers E.G.M. and de Boer I.J.M. (2005). Risk for *Salmonella* enteritidis infections in laying hens. *Poult. Sci.* **84,** 1308-1313.

Patterson P., Koelkebeck K., Bell D., Carey J., Anderson K. and Darre M. (2001). Egg marketing in national supermarkets, specialty eggs. *Poult. Sci.* **80,** 390-395.

Pavlovski Z., Masic B. and Apostolov N. (1981). Quality of eggs laid by hens on free range and in cages. Pp. 231-235 in Proc. 1th European Smpos. Quality of Eggs. Apeldoom, the Netherlands.

Peebles E.D., Zumwalt C.D., Doyle S.M., Gerard P.D., Latour M.A., Boyle C.R. and Smith T.W. (2000). Effect of breeder age and dietary fat source and level on broiler hatching egg characteristics. *Poult. Sci.* **70,** 698-704.

Protais J., Queguiner S., Boscher E., Piquet J.C., Nagard B. and Salvat G. (2003). Effect of housing systems on the bacterial flora of egg shells. *Br. Poult. Sci.* **43,** 788-789.

Radon K., Danuser B., Iversen M., Monson E., Weber C., Hartung J., Donham K.J., Palmgren U. and D. Nowak. (2002). Air contaminants in different European farming environments. *Ann. Agric. Environ. Med.* **9,** 41-48.

Silversides F.G. and Scott T.A. (2001). Effect of storage and layer age on quality of eggs from two lines of hens. *Poult. Sci.* **80,** 1240-1245.

Tauson R. (2005). Management and housing systems for layers-effects on welfare and production. *World's Poult. Sci.* **61,** 477-490.

Van den Brand H., Parmentier H.K. and Kepm B. (2004). Effects

of housing system (outdoor *vs*. cages) and age of laying hens on egg characteristics. *Br. Poult. Sci.* **45,** 745-752.