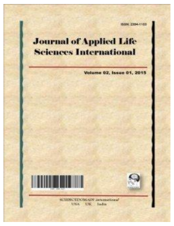

Journal of Applied Life Sciences International
3(3): 114-121, 2015; Article no.JALSI.2015.032
ISSN: 2394-1103

SCIENCEDOMAIN *international*
www.sciencedomain.org

Effect of Automatic Nests versus Conventional Nests on Laying Performance of Commercial Hens in Veracruz, Mexico

Alfredo Bartolo-Guerrero[1], Luis Antonio Landín-Grandvallet[2] and José Alfredo Villagómez-Cortés[2*]

[1]GAPESA, Cuatro Ciénegas No 1534-3. Saltillo, Coahuila, México.
[2]*Facultad de Medicina Veterinaria y Zootecnia, Universidad Veracruzana, Miguel Ángel de Quevedo y Yañez s/n, Col. Unidad Veracruzana, 91710, Veracruz, Veracruz, México.*

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2015/18662
Editor(s):
(1) Muhammad Kasib Khan, Department of Parasitology, University of Agriculture, Pakistan.
Reviewers:
(1) Anonymous, Bangladesh.
(2) Carla Falugi, Università di Genova, Italy.
Complete Peer review History: http://sciencedomain.org/review-history/10099

Original Research Article

Received 4th May 2015
Accepted 16th June 2015
Published 8th July 2015

ABSTRACT

Aims: To evaluate laying performance of heavy breeders housed either in conventional individual (CI) or group automatic (GA) nests.
Study Design: A simple experiment was used to compare 5700 breeders housed in pens with CI and 5500 kept in GA nests from 164 to 247 days of age.
Place and Duration of Study: Poultry farm "Los Corderos" located in Maltrata, Veracruz, Mexico for two months (March to May).
Methodology: Eggs were collected daily to assess cracked shells (CS) and dirty eggs (DE). Out of 23 hatching batches, the number of good chicks (GC), culled chicks (CC), and dead embryo (DE) were recorded and compared by group.
Results: Average CS was 65.8±22.3 in CI and 71±22.6 in GA whereas average DE was 11.6±10 and 23±20.4 respectively, finding a highly statistical difference (P = .01). In regard to GC, average was 10330±4418 in CI and 9781±4157 in GA. Average CC was 124.65±50.64 in CI and 116.30±

**Corresponding author: Email: avillagomez@uv.mx;*

47.64 in GA. Average DE was 664.26±219.35 in CI and 642.74±218.68 in GA. No significant difference was found for GC, CC or DE (P = .05). A higher amount of CS and DE were observed in GA. This may be explained by hens' preference for laying in CI. Hence, more CS and DE appear in GA, which in turn reduce egg hatching, and consequently, decrease the chances of obtaining GC.
Conclusion: Laying performance of heavy breeders did not improve by using group automatic when compared to conventional individual nests.

Keywords: Egg industry; broiler breeder; animal welfare; production systems; environment.

1. INTRODUCTION

The critical factors affecting the economic performance of poultry include genetics, nutrition, management and health. There is no easy answer for deciding which factor is the most important. Determining which element affects the most is a complicated task because there is a chain of events in which a simple factor such as the quality of bed can affect another one. It is obvious that for a successful poultry production there are many factors involved [1,2]. Poultry industry has been developing quantitatively and qualitatively, causing neither production nor consumption levels remain static [3].

Poultry industry in the United States has been under pressure from many directions to change its production practices. Changes in consumer demand and in legislation promote alternative group housing systems for laying hens. One current main concern is hen welfare in conventional cage systems [4]. By similar stresses, in 1999, the European Union banned conventional laying cages starting in 2012 [5]. However, in the predominant poultry production systems of the rest of the world, laying of eggs outside nest boxes is a common problem in poultry production systems [6], hence nests automation is essential for a more efficient farming, even though its operation should be continuously monitored in order to collect quality eggs [4]. Production depends not only on the selected nest, but also on the construction, installation and subsequent management of the whole, including hens.

In broiler breeder production systems nests are the most important piece of equipment. Nests have been modified over time to save labor and ensure a quick collection of quality eggs [7]. Nevertheless, farmers doubt that technology applied to nests, actually has the ability to produce quality eggs and increase the efficiency of hens. Investing in the acquisition of this material and its maintenance costs should also be taken into account, since it can significantly increase expenditures [8]. Poultry producers in Mexico want to know if the use of nests with automatic eggs collectors performs better than conventional nests, which for years have maintained a competitive quality in egg production. Hence, the objective of this study was to compare the benefits of conventional and automated nests based on the productive parameters of broiler breeders in Veracruz, Mexico.

2. MATERIALS AND METHODS

2.1 Location

The research was conducted on the premises of the farm "Los Corderos" owned by Avicultores Cordobeses Asociados S.A. de C.V. and located in the town of Maltrata, Mexico. This municipality is located in the eastern state of Veracruz at an altitude of 1771 meters above sea level. The climate is temperate and wet, annual temperature range from 5 to 20ºC and freezing occurs year-around.

2.2 Birds and Research Design

Two lots of Ross 308 hens were used, the first with 5500 birds housed in a pen with automatic nests and the second with 5700 birds housed in a pen with conventional nests. Each nest was equipped with an automatic water supply and feeding troughs. The type of nest (conventional or automatic) was considered as treatment. The two treatments were assessed from 164 to 247 days in life of hens. This 12-week period comprised laying onset, peak production and diminishing laying capacity.

Data were collected on the spot where the egg was laid (nest or soil) in both treatments. The amounts of cracked and dirty shells, as well as the number of eggs lay in nests and on floor were quantified. Double and deformed eggs were not included in the study because their production is not a function of the nests in which they were collected. The number of good chicks, culled chicks and dead embryos were obtained from records of the incubator and used to assess the quality of hatching eggs.

Fig. 1. Conventional nest

Fig. 2. Automatic nest

2.3 Farm Management

Birds were separated into two areas, the breeding and the production area. A third area was devoted to handling eggs. Hens were lodged in semi-dark pens and managed in an all in - all out policy. Males were reared in open houses in a natural environment. The feeding and lighting programs used for hens are those recommended by the stock supplier [9]. The vaccination program was designed for common diseases, including Gumboro Disease, Newcastle Disease, Infectious Bronchitis, Reovirosis Infection, Avian Encephalomyelitis, Chicken Anaemia, Avian Infectious Laringotracheitis, Avian Pox, Fowl Cholera and Fowl Coryza. The production area had thirteen houses furnished with both automatic and manual nests. Management in both types of nests was similar and involved progressively increasing the amount of food offered and lighting based on the standards recommended by the breeding supplier. The food was provided by Agropecuaria ACA, a partner of the same company, Avicultores Cordobeses Asociados.

2.4 Statistical Analysis

Three classes of variables were measured: variables concerning laying traits, those related to egg abnormalities and those regarding hatchability. Egg production was recorded every day from the first laid egg up to 247 days-old. The descriptive statistics of the variables under study were performed and the mean values of treatments (nests type) were compared using Student's t test in SPSS version 15.0 for Windows. Statistical significance was declared at 0.05.

3. RESULTS AND DISCUSSION

The preferences of laying hens for different nest sites have scarcely been examined under commercial conditions [10], and most studies neglected the related productive aspects.

3.1 Laying Place

After 12 weeks, conventional nests had 98.3% of eggs laid in nest boxes and 1.6% laid on the floor; hens housed in stalls with automatic nests had 95.5% and 4.4%, respectively. This finding is similar to that described by Buxadé [11] in Spain after 67 weeks in laying, where in nests with manual collection, eggs laid on floor and in slats represented 0.6% and 1.1%, whereas in nests with automatic collection accounted for 1.94% and 1.73%, respectively. Table 1 summarizes all research findings.

Banga-Mboko et al. [12] compared the response of Lohmann laying hens raised either in battery cages or on the floor in a deep litter in Congo Brazzaville, and found that the hens had a 70.8% laying rate in battery cages, but dropped to 45.5% when kept on floor pens.

A study done with laying hens kept in an aviary system under Swedish conditions found that the proportion of misplaced eggs (floor eggs) seemed to be influenced by rearing, but it was also observed some variation between different pens within batch, ranging from 0.7 and 18.4% in five trials [13].

Table 1. Comparison between conventional and automatic nests during the first twelve weeks of production of commercial laying hens in Veracruz, Mexico

	Conventional nests	Automatic nests
Laying place		
In nests, no. (%)	294 380a (98.3)	272 130 a (95.5)
On floor, no. (%)	5 041a (1.6)	12 727b (4.4)
Total eggs	299 421a	284 857a
Average laying		
In nests, no.	3504.52a±1222.3	3239.64b±1125.6
On floor, no.	60a±45.9	151.5b±88.9
Hatchable eggs, no.	3277.9a±1273.3	3136.2b±1143.1
Cracked shells, no.	65.8a±22.3	71b±22.6
Dirty shells, no.	11.6a±10	23b±20.4
Abnormal eggs		
Cracked shells, no. (%)	5527a (1.84)	5961b (2.09)
Dirty shells, no. (%)	972a (0.32)	1934b (0.67)
Hatchability		
Good chicks, no. (%)	237 599a (82.70)	224 966a (82.58)
Culled chicks, no. (%)	2 867a (1.23)	2 675a (1.28)
Death embryos, no. (%)	15 278a (6.95)	14 783a (6.80)
Total hatched eggs, no.	274 824a	261 355a
Average hatchability		
Good chicks, no.	10330.39a±4418.52	9781.13a±4157.14
Culled chicks, no.	124.65a±50.64	116.30a±47.64
Death embryos, no.	664.26a±219.35	642.74a±218.68

** Different letters by row indicates statistically significant difference (P = .05)*

3.2 Average Laying

Significant statistical difference were found in all the variables (P = .01). This may be due to the fact that in the conventional-nesting huts there is no noise from the conveyor belt as in the automatic nest; in addition, conventional nests usually have better lighting, which appeals more to the hen in search of a place to lay their eggs [14]. Floor eggs could be reduced by increasing the frequency of eggs collection during the first weeks of production. This practice prevents hens to get used to seeing eggs on the ground, and also prevents the future presence of high percentages of floor eggs [15]. From eight or ten weeks-old on, the use of perches in breeding houses would also be useful as it would encourage hens to climb and would reduce their reluctance to enter the nest. Cages with nest boxes and perches offer appreciable benefits for welfare, with few production problems [16]. It would be better if perches are made of the same material as nests are [17]. However, Thurner et al. [18] working with hybrid layers were unable to observe clear preferences for some nest boxes. Also, in trials with and without an enclosed nest box, Cooper and Appleby [19] concluded that nest-seeking behavior was independent of prior experience of nesting. It is noteworthy that in conventional wire cages, hens have little opportunity to perform either nest seeking or nest building activities, which may lead to frustration each time an egg is laid [19]. According to Cooper and Appleby [20], hens are willing to pay a high energy cost to gain access to a nest box prior to oviposition, so pre-laying behavior may be frustrated in hens without a well-defined, littered nest site.

As hens grow old, laying in nests increases because hens have full knowledge of their environment. At an early production stage there is an increased number of floor eggs, since laying percentage in the flock is smaller compared to that obtained at the peak of production; also, hens that are used to lay eggs on the floor usually always place them on the same site, so this is a difficult behavior to eliminate. The sooner the problem of floor eggs is corrected fewer problems will be in the flock, considering that as egg production increases the percentage of eggs in the soil should fall quickly. As age advances, egg production rate decreases and egg weight increases [21]. Egg quality and composition also change in accordance with level of production and age of layer. Buxadé [11] mentions that by the 68 week hen breeders lay 1.87% of eggs in slats or on floor with manual collection and 2.38% when the collection is automatic.

3.3 Abnormal Eggs

In conventional nests, cracked shells represented 1.84% and dirty shells 0.32%. In automatic nests the corresponding values were 2.09% and 0.67% respectively. The amount of cracked and dirty shells was higher in automatic nests because they had a higher percentage of floor eggs. However, results were very similar up to week 10, when automatic collection dropped as a consequence of a failure in the conveyor belt. In the meantime, eggs were manually collected and as a consequence the number of cracked shells increased. Furthermore, nests cannot be operated to expel the hens and a number of eggs rested in the nest and were more prone to crashing. In automatic nests, the causes of broken shell were mainly due to shell shock when eggs were displaced to the conveyor belt, by manipulation at collection times, and when the belt conveyor was broken. In conventional nests, the shell was broken by the passage of the hens in the nest, by pecking and sometimes, for lack of proper conditioning of the nest.

In the Banga-Mboko et al. [12] study, the battery cages system produced 1.08% more broken eggs, but there was no difference in egg and shell quality between the studied groups.

In connection with dirty shell, as laying on the floor increases, so does the number of dirty shells; to prevent this situation, floors and hallways should be checked at least five times a day. First inspection must coincide with birds feeding, and each successive one must precede the conveyor belt operation [22]. While some hens lay eggs early, almost before turning on the lights, checking nests every hour is strongly recommended to collect eggs from the floor and recovering a small amount of eggs that may have potential hatchability after proper treatment.

3.4 Effects of Incubation on Collected Eggs

Only fertile eggs in both treatments were considered to evaluate the quality of one day-old chicks. Embryo mortality in the incubation lot was evaluated by day 12 using an ovoscopy. In 23 hatchings from eggs laid in the first twelve weeks of breeders' production, conventional nests had in average 90.88% fertile eggs against a 90.65% for automatic nests. After 19 days in the incubator, the egg was transferred to the hatcher and the incubation phase was completed. Reasons for low hatchability could be improper management of the breeder flock, an incorrect incubation procedure, or a failure within any step between the breeder flock and the final hatch [23].

In pens with automatic nesting there are always some hatching eggs laid on the floor. Given the existing risk of contamination, these eggs should be handled carefully to prevent a lower number of quality chicks. In conventional nests, as most eggs are in contact with hens after being laid, they get contaminated with feces and bed particles, so germs can penetrate them resulting in a greater number of dead embryos.

A number of factors affecting hatchability have been studied for diverse authors. This include breeders line, health, nutrition and age of the flock, egg size, weight and quality, egg handling and storage condition, egg storage duration, incubation conditions such as temperature, humidity, turning frequency, ventilation, and egg orientation, egg sanitation, and season of the year [24-36].

Despite a greater number of eggs laid on floor are collected in pens with automatic nests and subsequently cleansed, the number of quality chicks obtained is similar to that obtained from conventional nests where eggs remain in direct contact with hens between collections and became polluted. In the case of automatic nests such contact is avoided, since the conveyor belt helps to keep hatching eggs in better shape. Floor eggs pose a potential hygiene problem and therefore should not be allowed. A greater number of culled chicks were collected from pens with automatic nests because there was a higher percentage of hatching eggs placed on the floor, which in turn affected negatively the potential quality of the chick. Subsequent observations indicated a poor selection of chicken and egg hatching mismanagement. As a reduction in the number of floor eggs in both treatments occurred, the amount of dead embryo also decreased. Over time, Figures of floor eggs for automatic nests were always above those for conventional nests.

Care and transfer of embryos from farm to the hatchery should be done with utmost care and attention. A sudden movement, poor disinfection, and a long stay on the farm weaken the quality of the embryo that is trapped in the egg [37]. In order to achieve eggs reaching a physiological zero at a similar stage of development, some procedures should be established to ensure a uniform cooling at 20-21ºC within four hours after collection in nests s done. Results in automatic nests can be improved if eggs do not stay a long time on the conveyor belts, since these do not carry appropriate environmental conditions, resulting in a reduction in chances of obtaining a healthy chicken; also, ventilation becomes inadequate as temperature exceeds 27ºC. Regarding conventional nests, the main problem is for the eggs that are left overheating in the nest, when the nest is occupied by another hen [38].

To produce with quality requires a complex process involving hen management in aspects such as nutrition, level of antibodies against prevalent diseases, eggs management and conservation, incubation, hatching process, transport and reception at the broiler farm. Chick quality is a topic that is often spoken about, but there is no precise definition or a method implemented in the industry that allows comparing, quantifying and repeating practices in different places and companies [39,40].

4. CONCLUSION

Empirical observation resulting from this study shows that hens prefer individual nests rather than automatic nests, also hens housed in individual stalls with conventional nests laid fewer eggs on ground that hens grouped and housed in stalls with automatic nesting facilities. In stalls provided with automatic nests, egg quality decreases significantly since more cracked and dirty shells are obtained reducing the production of eggs with proper hatching characteristics. In the incubator, egg hatchings obtained either from conventional or automatic nests were similar in terms of first-class chicken, wasted-class chicken, and embryo death. Under the conditions of this study and the parameters evaluated, automatic nests did not perform better than conventional nests. Results for the former may improve if the amount of cracked and dirty shell could be reduced.

ETHICAL APPROVAL

All authors hereby declare that Mexican Official Standard NOM- 062 -ZOO- 1999, related to technical specifications for the production, care and use of animals in experiments was closely abided by. All experiments have been examined and approved by the Committee on Bioethics and Animal Welfare, School of Veterinary Medicine and Animal Sciences, University of Veracruz.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hammerstedt RH. Symposium summary and challenges for the future. Poult Sci. 1999;78(3):459-466.
   DOI: 10.1093/ps/78.3.45
2. King'ori AM. Review of the factors that influence egg fertility and hatchabilty in poultry. Intern J Poult Sci. 2011;10(6):483-492.
3. Sumner DA, Gow H, Hayes D, Matthews W, Norwood B, Rosen-Molina JT, Thurman W. Economic and market issues on the sustainability of egg production in the United States: Analysis of alternative production systems. Poult Sci. 2011;90(1): 241–250.
   DOI: 10.3382/ps.2010-00822.
4. Mench JA, Sumner DA, Rosen-Molina JT. Sustainability of egg production in the United States—The policy and market context. Poult Sci. 2011;90(1):229-240. DOI: 10.3382/ps.2010-00844.
5. Appleby MC. The European Union ban on conventional cages for laying hens: History and prospects. J Appl Anim Welf Sci. 2003;6(2):103–121.
   DOI: 10.1207/S15327604JAWS0602_03
6. Gunnarsson S. Keeling LJ, Svedberg J. Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. Brit Poult Sci. 1999;40(1):12-18.
   DOI: 10.1080/00071669987773.
7. Appleby MC. Modification of laying hen cages to improve behavior. Poult Sci. 1998;77(12):1828–1832.
   DOI: 10.1093/ps/77.12.1828.
8. Lokhorst C, Vos HW. An automatic egg weighing and counting system for detailed analysis and control of egg production. J Agric Eng Res. 1994;57(2):137–144.
   DOI: 10.1006/jaer.1994.1013.
9. Aviagen. Parent Stock Management Manual ROSS308. Aviagen Incorporated. Huntsville, Alabama. 2013;174.

Available:http://es.aviagen.com/assets/Tech_Center/Ross_PS/Ross_PS_Handbook_2013_i-r1.pdf

10. Lentfer TL, Gebhardt-Henrich SG, Fröhlich EKF, von Borell E. Influence of nest site on the behaviour of laying hens. Appli Anim Beh Sci. 2011;135(1-2):70–77.
DOI: 10.1016/j.applanim.2011.08.016.
11. Buxadé CC. La gallina ponedora y sistemas de explotación y técnicas de producción. 2nd ed. Mundiprensa: Madrid; 2000. Spanish.
12. Banga-Mboko H, Mabas JS, Adzona PP. Effect of housing system (Battery cages versus floor pen) on performance of laying hens under tropical conditions in Congo Brazzaville. Res J Poult Sci. 2010;3(1):1-4. DOI: 10.3923/rjpscience.2010.1.4.
13. Abrahamsson P, Tauson R. Performance and egg quality of laying hens in an aviary system. J Appl Poult Res. 1998;7(3):225-232.
DOI: 10.1093/japr/7.3.225.
Available:http://japr.oxfordjournals.org/content/7/3/225.short
14. Appleby MC, McRae HE, Peitz BE. The effect of light on the choice of nests by domestic hens. Appl Anim Ethol. 1984;11: 249–254.
Available:http://dx.doi.org/10.1016/0304-3762(84)90031-2
15. Vencomatic. Handbook for heavy breeders. The Center-Belt Nest. Vencomatic Inc: Calgary, Alberta, Canada; 2001.
16. Appleby MC, Smith SF, Hughes BO. Nesting, dust bathing and perching by laying hens in cages: Effects of design on behaviour and welfare. Br Poult Sci. 1993; 34(5):835-847.
DOI: 10.1080/00071669308417644.
17. Sbanotto P. Minimizing floor and slat egg problems. Technical Focus Cobb. 2006; 1(1):1-4.
Available:http://www.cobb-vantress.com/publications/documents/focus_tech_1-06.pdf
18. Thurner S, Wendl SG, Preisinger R. Funnel nest box: A system for automatic recording of individual performance and behaviour of laying hens in floor management. Paper 52, Proceedings of the XII European Poultry Conference. 10-14 September 2006. Verona, Italy: World Poultry Science Association; 2006.
19. Cooper JJ, Appleby MC. Nesting behaviour of hens: Effects of experience on motivation. Appl Anim Behav Sci, 1995; 42:283-295.
DOI: 10.1016/0168-1591(94)00543-N.
20. Cooper JJ, Appleby MC. Demand for nest boxes in laying hens. Beha. Proc. 1996; 36:171-182.
21. Summers JD, Leeson S. Factors influencing early egg size. Poult. Sci. 1983; 62:1155-1159.
DOI: 10.3382/ps.0621155.
22. Brake J. Equipment Design for Breeding Flocks. Poult Sci. 1998;77(12):1833–1841. DOI:10.1093/ps/77.12.1833.
23. Yassin H, Velthuis AGJ, Boerjan M, van Riel J, Huirne RBM. Field study on broiler eggs hatchability. Poult Sci. 2008;87(11): 2408–2417.
DOI: 10.3382/ps.2007-00515.
24. Kirk S, Emmans GC, Mcdonald R, Arnot D. Factors affecting the hatchability of eggs from broiler breeders. Br Poult Sci. 1980; 21:37–53.
DOI: 10.1080/00071668008416633.
25. Wilson HR. Interrelationships of egg size, chick size, post hatching growth and hatchability. Wrld. Poult. Sci. J. 1991;47:5–20.
Available:http://dx.doi.org/10.1079/WPS19910002
26. Wilson HR. Effects of maternal nutrition on hatchability. Poult. Sci. 1997;76(1):134–143.
DOI: 10.1093/ps/76.1.134.
27. Vieira SL, Mora Jr. T. Eggs and chicks from broiler breeders of extremely different age. J. Appl. Poult. Res. 1998;7:372–376.
DOI: 10.1093/japr/7.4.372.
28. Lapao C, Gama LT, Soares MC. Effects of broiler breeder age and length of egg storage on albumen characteristics and hatchability. Poult Sci. 1999;78(5):640–645.
DOI: 10.1093/ps/78.5.640.
29. Christensen VL, Wineland MJ, Fasenko GM, Donaldson WE. Egg storage effects on plasma glucose and supply and demand tissue glycogen concentrations of broiler embryos. Poult Sci. 2001;80:1729–1735.
DOI: 10.1093/ps/80.12.1729.
30. Elibol O, Peak SD, Brake J. Effect of flock age, length of egg storage, and frequency of turning during storage on hatchability of

broiler hatching eggs. Poult Sci. 2002;81: 945–950.
DOI: 10.1093/ps/81.7.945.

31. Tona K, Onagbesan O, De Ketelaere B, Decupere E, Bruggeman V. Effect of age of broiler breeders and egg storage on egg quality, hatchability, chick quality, chick weight and chick post hatch growth to forty-two days. J. Appl. Poult. Res. 2004; 13:10–18.
DOI: 10.1093/japr/13.1.10.
32. Tona K, Bruggeman V, Onagbesana O, Bamelis F, Gbeassor M, Mertens K, Decuypere E. Day-old chick quality: Relationship to hatching egg quality, adequate incubation practice and prediction of broiler performance. Avian Poult. Biol. Rev. 2005;16:109–119.
Available:http://dx.doi.org/10.3184/147020605783438787
33. Joseph NS, Moran Jr ET. Effect of age and post emergent holding in the hatcher on broiler performance and further processing yield. J. Appl. Poult. Res. 2005;14:512–520.
34. Samli HE, Agma A, Senkoylu N. Effects of storage time and temperature on egg quality in old laying hens. J. Appl. Poult. Res. 2005;14:548–553.
35. Decuypere E, Bruggeman V. The endocrine interface of environmental and egg factors affecting chick quality. Poult Sci. 2007;86:1037–1042.
DOI: 10.1093/ps/86.5.1037.
36. Fasenko GM. Egg storage and the embryo. Poult Sci. 2007;86:1020–1024.
DOI: 10.1093/ps/86.5.1020.
37. Butcher DD, Nilipour AH. Management of hatching eggs and broiler performance. Veterinary Medicine-Large Animal Clinical Sciences Department, Florida Cooperative Extension Service. Gainesville, FL: Institute of Food and Agricultural Sciences, University of Florida; 2008.
Available:http://edis.ifas.ufl.edu/pdffiles/VM/VM09400.pdf
38. Watts D. Management of egg size, egg handling and egg storage. Poult Wrld. 2004;158(5):52-53.
39. Rose SP. Principles of poultry science. Wallingford, England: CABI; 1996.
40. Sainsbury D. Poultry health and management. Chickens, Turkeys, Ducks, Geese and Quail. Fourth ed. Oxford: Wiley-Blackwell Science; 2000.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/10099