Research Article

www.dergipark.org.tr/en/pub/mediterranean

MEDITERRANEAN AGRICULTURAL SCIENCES
(2024) 37(2): 99-103
DOI: 10.29136/mediterranean.1443067

Incubation characteristics and their relation to the age of the parent flock for broiler production

Atanas GENCHEV, Hristo LUKANOV, Todor PETROV

Trakia University, Faculty of Agriculture, Department of Animal Science, 6000, Stara Zagora, Bulgaria

Corresponding author: H. Lukanov, e-mail: hristo.lukanov@trakia-uni.bg
Author(s) e-mail: agenchev@abv.bg, todor.petrov.20@trakia-uni.bg

ARTICLE INFO

Received: February 27, 2024
Received in revised form: June 14, 2024
Accepted: June 16, 2024

***Keywords*:**

Hatching eggs
Incubation
Hatchability
Vital chickens

ABSTRACT

The aim of this study was to examine the incubation characteristics of hatching eggs from one of the widely distributed hybrid combinations of classic broilers globally and to trace the dynamics of their changes depending on the age of the parental flock. The study covered a 12-year period - between 2011 to 2023. The share of quality chicks hatched ranged from 76.8% to 91.6%, with average values of 84.1-84.3%, while the share of culled chickens was within the normal range (0.4 to 1.7%). The proportion of culled eggs during candling on the 7th day varied between 4.3% and 14.7%, with average values of 7.64-8.24%. With the increase in the age of the parental flock, there was a stable tendency to increase the share of culled eggs at the first test egg cull, particularly due to the increase of the share of infertile eggs. The age of the parental flock determined more than 38% of the manifestation of the egg fertility trait and about 45% of that of quality chicks. Its influence on total embryonic mortality was significantly weaker (R^2= 0.1456). The study of the relationship between the traits "share of quality chicks" and "share of infertile eggs" showed that in the examined dataset, the correlation between them was moderate, negative (r= -0.472±0.100 at P<0.001), with a linear character (L= 0.046±0.062).

1. Introduction

The hatchery, in its simplest definition, is an enterprise for egg incubation, hatching, and the delivery of chicks (EC 617/2008). It plays a crucial role in the breeding center – hatchery – broiler production chain (Yassin et al. 2008). According to definitions, industrial hatcheries, depending on their purpose, can operate as enterprises with closed or open production cycles (Official Gazette 2006). Closed-type hatcheries are integral parts of poultry complexes or large farms with a clearly defined production specialization and productivity direction. The process of incubation and hatching is a part of the overall technological process on the farm. Large, specialized poultry facilities for broiler chicken meat production usually have their own facilities for raising parental birds, hatcheries, feeding centers, and even their own slaughterhouses. In this way, their hatcheries always work with fresh eggs (up to 7 days after laying), providing direct information about hatchability and incubation performance related to the flock and the age of the birds.

Non-specialized industrial hatcheries do not have a clearly defined production specialization and productivity direction. They are usually not linked to their own production of hatching eggs and operate as independent enterprises. Throughout different periods of the year, depending on the specific market needs, eggs from various productive directions (egg and meat production or dual-purpose) of the same bird species can be hatched, intended for both industrial farms and small producers, and even for personal use in the backyard poultry farming (Genchev and Lukanov 2023).

Farms specializing only in the production of hatching eggs can be standalone units or more often are found in combination with a hatchery. In these conditions, they operate only in the hatching egg market, and for economic reasons, their hatcheries are primarily loaded with eggs that cannot be sold on the market. As a result, they do not always have objective and reliable information about the real incubation qualities of the eggs they offer on the domestic or international market. In such a work scheme, the only way to have reliable information is through feedback with trusted hatcheries to which they sell guaranteed fresh hatching eggs obtained from parental flocks of a certain known age.

Considering these circumstances, the aim of this study was to examine the incubation characteristics of the hatching eggs and track the dynamics of their change depending on the age of the parent flock for one of the widely distributed hybrid combinations of classic broilers on a global scale.

2. Material and Methods

The study covered a 12-years period: from 2011 until 2023. The presented results are based on samples of over 243000 incubated eggs from the Ross 308 hybrid (Aviagen®). The study explored the dynamics in the incubation characteristics of eggs obtained from parent stock between 28-49 weeks of age.

During the specified period, two farms, significant producers of broiler eggs in Bulgaria, supplied the hatchery with hatching eggs. From 2011 to 2016, the supplier was "Farm 1", based in

Northwestern Bulgaria. From 2017 to 2023, hatching eggs were supplied from "Farm 2", located in the central part of Southern Bulgaria. Both facilities provided information on the age of the parental flocks and the date of egg collection.

Transport conditions, egg storage until setting into the incubator, incubation and hatching regimen corresponded to the requirements for meat type hybrids of the chicken species (Genchev and Lukanov 2023). During loading into incubation trays, eggs with compromised shell integrity, those with contamination, deformities, and other shell-related issues, as well as deviations in the egg shape and weight, were separated as "unsuitable for incubation eggs". All loaded eggs were candled on the 7th day of incubation, at which point the incubation cull was recorded as "culled eggs at first candling". The number of hatched healthy chicks ("quality chicks") and those culled due to deviations from the norm ("culled chicks") was documented during hatching. The quantity of unhatched eggs was recorded at the end of incubation. According to the technology used in the country for chicken quality, chickens are classified as good (class A) or acceptable (class B) quality if they meet the following requirements: vital and active, without visible developmental disorders; the down - dry, clean, sufficiently long and shiny; the eyes - wide open, shiny and protruding; the legs - without swelling and hemorrhages; the navel - clean and completely closed. All day-old chicks that do not meet these requirements are classified as class C (culling).

The results obtained were compared to the quantity off eggs loaded for incubation, calculated the share of:

- culled eggs at first candling (%) – unfertilized eggs and eggs with embryos dead by the 7th day.

- quality chicks (%) – quality chicks suitable for rearing.

- culled chicks (%) – hatched chicks with various physical defects, deformities, and other quality deviations incompatible with further rearing.

- unhatched eggs (%) – eggs with embryos dead between the 7th -21st days. Mortality in the middle and at the end of incubation, technological culling from eggs with compromised shell integrity during the incubation period, were covered.

Statistical analysis was conducted using specialized software IBM® SPSS® Statistics (V26). The statistical comparison was made by the least significant difference (LSD) test at the 95% probability level. All data werereported as mean ± standard error of the mean (x±SEM). Statistical significance was established at $P<0.05$. Dispersion analysis and calculations for elucidation of the strength of the influence of individual factors on the determination of the studied traits were made. The graphical design was created by using Microsoft Excel 16.0 (2018, for Windows).

3. Results and Discussion

The results presented in Figure 1 show that the average share of eggs not suitable for incubation purchased from Farm 1 varied between 0.24% - 0.91%. Although within normal limits, this number of culled eggs reflects on the value of the purchased hatching eggs, increasing their relative price on average by 0.49%. For eggs purchased from Farm 2, the share of culled eggs was more than 2 times higher and, over the study period, averages up to 1.20%, with variation in the average values over the individual years ranging from 0.69% to 1.71%. This leads to an increase in production costs at the hatchery by an average of 1.46%. If we consider a comparable average value of 0.28 EUR for a hatching egg based on international prices, the difference between the two farms reached 2.88 EUR per 1000 eggs set.

Comparing the results of the culled eggs at first candling we did not find a significant difference between both farms (Table 1). The percentage of culled eggs during candling on the 7th day in the individual hatching batches ranged from 4.3% to 12.6% for Farm 1 and from 5.7% to 14.7% for Farm 2. The analysis of the degree of dispersion of values for the studied characteristic shows that the sample is approximately homogeneous (CV 26.4% for Farm 1 and 22.4% for Farm 2). The result obtained is within normal limits for the hybrid (Yousaf et al. 2018), considering the fact that over different years, egg from parents of different ages have been loaded into the hatchery.

The most crucial factor determining the efficiency of a hatchery is the hatchability from eggs set, particularly the share of quality chicks. The current understanding of the limits of the hatchability from eggs significantly differs from that of 30 years ago. Until the early 1990s, it was considered normal, in broiler production, for hatchability to be within the range of 78-80%, but not lower than 75% (Markaryan et al. 1986; Danilova et al. 1987; Fisinin et al. 1988; Burtov et al. 1990). However, for modern high-productivity broiler hybrids, cumulative hatchability below 80% for the whole productive period of parental birds is deemed unacceptable (Cobb-Vanress 2020; Aviagen 2021; Hubbard Breeders 2022). According to Pizzari (2017), the goal is to achieve an average hatchability of 83% for the 40-week productive period of the parent's stock of the Ross 308 hybrid.

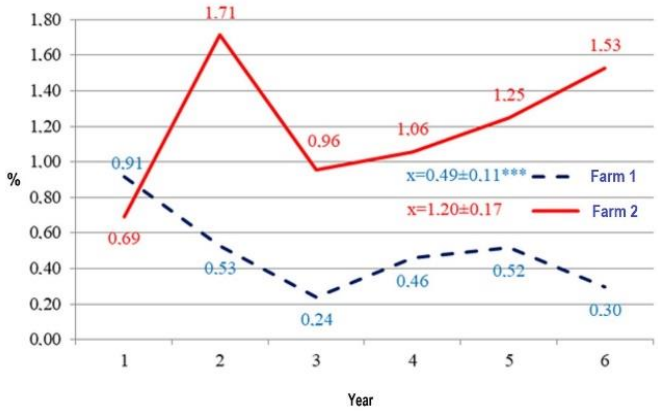

Figure 1. Share of the unsuitable eggs for incubation, %.

Table 1. Incubation characteristics, % from the eggs set

Years	Parameters*			
	1	2	3	4
		Farm 1		
2011	9.34±0.43	83.10±0.57	0.74±0.06	6.82±0.37
2012	5.58±0.27	87.94±0.64	1.10±0.01	5.38±0.49
2013	7.22±0.67	84.72±0.67	0.80±0.06	7.25±0.20
2014	5.05±0.31	83.05±0.76	1.18±0.14	7.54±0.63
2015	6.83±0.36	83.27±1.19	1.07±0.02	8.73±1.02
2016	9.57±0.63	80.41±0.94	1.08±0.02	8.94±0.99
Average	7.64±0.25	84.07±0.42	0.99±0.03	7.28±0.28
min-max	4.33÷12.63	76.84÷91.60	0.37÷1.77	1.79÷14.57
		Farm 2		
2018	7.23±0.31	84.84±1.04	1.09±0.02	6.84±0.75
2019	9.43±0.49	82.92±0.39	1.02±0.03	6.63±0.50
2020	7.75±0.65	86.02±1.06	1.08±0.02	5.14±0.55
2021	7.76±0.58	84.81±0.71	1.09±0.01	6.35±0.47
2022	7.74±0.43	84.33±0.49	0.98±0.06	6.95±0.30
2023	10.37±1.44	81.86±1.44	0.75±0.16	6.98±0.40
Average	8.24±0.28	84.33±0.37	1.02±0.02	6.41±0.22
min-max	5.70÷14.74	78.48÷89.22	0.23÷1.16	3.59÷10.08

Note: * 1. culled eggs at first examination; 2. quality chicks; 3. culled chicks; 4. unhatched eggs.

Our results indicate that for individual hatching batches, over the entire study period, the proportion of hatched quality chicks ranged from 76.8 to 91.6% for eggs from Farm 1 and 78.5-89.2% from Farm 2. The average values for this trait between both farms are practically indistinguishable, and the low coefficient of variation indicates high uniformity in the sample (CV 2.9-3.9%). The proportion of hatched but culled chicks for both farms ranged between 0.23 and 1.7%, which is within the normal range for hatchery practices (Orlov 1987; Mymrin 1989), complies with standards for meat-type hybrids (Buryan 2006; Mailyan 2009; Genchev and Lukanov 2023).

Reviewing literature on embryonic mortality in the Ross 308 hybrid between the 7th and 21st days, we found that the norms are highest during the chick hatching phase, ranging from 2.5-3.5% (Tullet 2009). This mortality is influenced by the age of the parental flock, with higher mortality at the beginning (up to peak of egg laying) and at the end of the productive cycle (after 50 weeks of age) (Yousaf et al. 2018). Cumulative culling from "unhatched eggs", according to hybrid producer, may reach 4.5-6.5% of eggs set (Tullet 2009). Other authors suggest a lower cumulative culling for the entire productive period, up to 4% (Dyadichkina 2016), but it can also reach 8-10% of eggs set (Markaryan et al. 1986; Burtov et al. 1990). Comparing our results, we found that average values during the study period varied between 5.12 and 8.94%, consistent with those presented in cited literature.

Analyzing the results, accounting for the age of the parental flock, reveals a consistent trend of increasing culling rates upon initial inspection (7th day) overlapping with that of the share of unfertilized eggs (Figure 2). The studied production period shows that early embryonic mortality ranges from 2.1 to 4.3% of eggs set, comparable to published Ross hybrids norms (Tullet 2009), confirmed and by Yousaf et al. (2018).

One of the most important components of egg culling up to the 7th day is the share of unfertilized eggs. In Figure 2, it is observed that up to the age of 39 weeks, their percentage slowly changes from 2.2-2.3% at 30-33 weeks of age to 3.7-3.9% in the period of 35-39 weeks. The results obtained during the peak laying phase of the parental flock are comparable to the norms for the same period outlined in the technological documentation of the other two leading broiler hybrid producers, Cobb and Hubbard (Cobb-Vantress 2020; Hubbard Breeders 2022). From the age of 40 weeks, the proportion of infertile eggs increases more intensively and reaches its peak levels between 42 and 44 weeks of age. Usually, this is the age at which, in practice, same age roosters from different housing areas are exchanged, or some of the less active roosters in the flock are replaced with younger ones. The purpose of such measures is to maintain hatchability at a satisfactory level by increasing the fertility of the eggs in the parental flock (Pizzari 2017). The observed decrease in the percentage of infertile eggs during the 46-49 weeks studied age period confirms the aforementioned.

Another trait with a high relative "weight" for the final incubation result is the embryonic mortality between the 8th and 21st days. While mortality in the middle stage of incubation (8-18 days) is insignificant and usually within the range of 0.5-1% of eggs set, embryonic mortality in the 18-21 day period reaches 3-6% (Dyadichkina 2016; Yousaf et al. 2018). Figure 3 presents the results of embryonic mortality for the 21-week period studied, including early mortality and the share of unhatched eggs.

During the specified period, the total embryonal mortality was most commonly within the range of 9 to 11% of eggs set, with two prominent peaks at 31 and 39-42 weeks of age of the parental flock. The reasons for these peaks vary. The first peak may be attributed to permissible errors in temperature control during both in egg cooling at farm level or in egg transport from the farm to the hatchery. The second peak's cause may be linked, on one hand, to the quality of the hatching eggs and, on the other hand, to a potential mistake during the hatching period. The total embryonal mortality for the studied period is close to the norm (7.5-11%) for the Ross 308 hybrid (Tullet 2009), and generally corresponds to the size of this cull in the other two world leading broiler hybrids Cobb 500 (6.7-11.3%) and Hubbard (6.6-10.7%) (Cobb-Vantress 2020; Hubbard Breeders 2022). Comparing embryonic mortality over different periods, we found that the share of early mortality constitutes 21.8-35.8% of the total embryonic mortality. A significantly larger percentage of

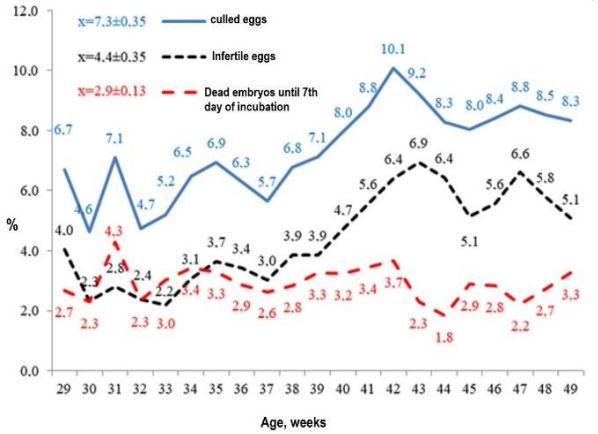

Figure 2. Culled eggs at first candling (7th day), % of eggs set.

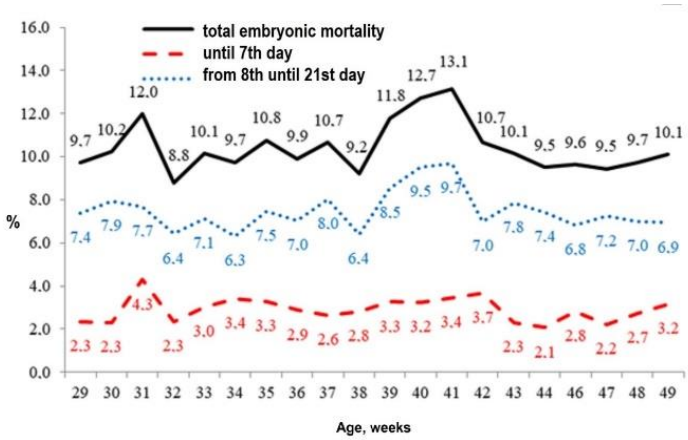

Figure 3. Embryonic mortality, % eggs set.

embryos die during the 8-21 day period, accounting for about 64.2-78.2% of the total mortality. Our result notably differs from literature data for this meat hybrid, with early embryonal mortality at 57.5% and late embryonal mortality at 38.4% (Peñuela and Hernandez 2018).

The culling due toinfertile eggs and embryonal mortality, determines the hatchability of the eggs set (Figure 4). The percentage of hatched broilers during the period studied varied between 82.4 and 88.8% of eggs set, which is close to the results of the best flocks of the Ross 308 hybrid (84.4-89.3%) (Aviagen 2021). Similar hatchability from the eggs set is also demonstrated by the best flocks of the other two widely used broiler hybrids globally (83.9-87.4% for Cobb 500 and 82.6-89.4% for Hubbard) (Cobb-Vantress 2020; Hubbard Breeders 2022). The cumulative hatchability rate in this study was over 85% of hatching eggs set, with the lowest values recorded during the 40-43 week of age (82.4-83.6%), coinciding with the peak of infertile eggs. This trait is dependent on the number of quality broilers, suitable for placement and further rearing, and the quantity of the low-quality chicks (culled chickens). The proportion of culled chickens is an indicator of compliance with the incubation and, most importantly, the hatching process. Over the study period, the reported percentage of culled chickens in the hatchery was within the range of 0.8-1.3%, fully aligning with modern standards (0.5-1.5%) for this trait (Dyadichkina 2016).

The share of quality broilers hatched, suitable for placement and further rearing, as well as hatchability, was negatively influenced by the age of the parental flock. The figure clearly shows that up to 39 weeks of age, the percentage of quality chicks hatched remained sustainably high (above 84% of hatching eggs set). After this age, the share decreased and was usually below 84%. A conducted analysis of variance for the results over the studied 21 week period shows that the influence of the factor "age of the parents" on the trait "quality chicks (%)" can be estimated at around 45% of the total variance (R^2= 0.4494). To a greater extent, the result is influenced by random factors such as the management of the parent flock, conditions and duration of egg transport and storage, fertility, embryonal mortality, incubation and hatching regimen, etc. (Genchev and Lukanov 2023).

Another trait dependent on the age of the parent flock is "egg fertility". Evidence of this could be found in the correlation between the decline in hatchability and the peak values of infertile eggs (Figure 2 and 4). The analysis of variance showed that the strength of the influence of the age of the parent flock can be estimated at over 38% of the total variance of the trait (R^2= 0.3878). Its influence on total embryonic mortality was significantly weaker (R^2= 0.1456). Studying the relationship between the traits "quality chicks (%)" and "infertile eggs (%)" revealed a moderate negative correlation in the analyzed dataset (r= -0.472±0.100 at P<0.001), with a linear character (L= 0.046±0.062). The valid equation for linear regression is y= -0.531x+89.685. The analysis indicates that the share of quality chicks is a dependent trait on egg fertility, and the strength of this influence can be estimated at around 22% (R^2= 0.223).

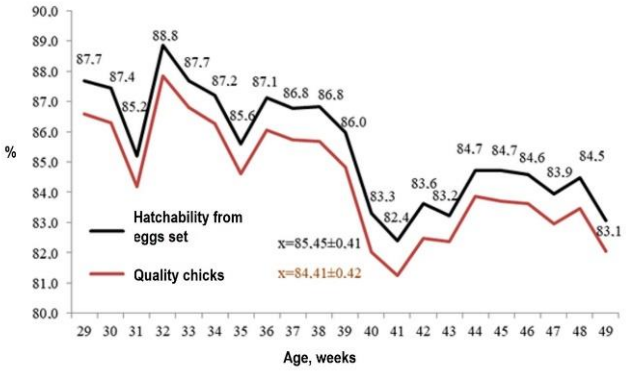

Figure 4. Hatchability and chick quality, %.

4. Conclusion

Based on the results obtained and the conducted analysis, we can conclude that the broiler chicken hatching eggs offered on both the domestic and international markets are of high quality. The proportion of quality chicks hatched is comparable to the target set by the hybrid combination's manufacturer, while culled chickens and culled hatching eggs fall within normal ranges. As the parental flock ages, there is a consistent trend of an increase in the culled eggs share during the first egg cull, primarily due to a rise in the percentage of infertile eggs. This constitutes a primary reason for the decrease in hatchability from the eggs set, which in turn affects the share of quality chicks.

References

Aviagen (2021) Ross 308 Parent Stock. Performance objectives. Available at: https://aviagen.com/assets/Tech_Center/Ross_PS/Ross308-EuropeanParentStock-PerformanceObjectives-2021-EN.pdf. Accessed 15 October, 2010.

Burtov YZ, Goldin YuS, Krivopishin IP (1990) Egg incubation. Handbook. Agropromizdat, Moscow. (in Russian)

Buryan M (2006) Progress in genetics stimulates changes in incubation technology. Ptitsefabrika 10: 21-23. (in Russian)

Cobb-Vantress (2020) Cobb500 Slow Feather Breeder: Management Supplement. Available at: https://www.cobb-vantress.com/assets/Cobb-Files/09cb72067f/Cobb500-Slow-Feather-Breeder-Management-Supplement.pdf. Accessed 08 October, 2023.

Danilova AK, Naydenskiy MS, Shpits IS, Yavorskiy VS (1987) Hygiene of industrial egg production. 2nd ed., Rosselkhozizdat, Moscow. (in Russian)

Dyadichkina LF (2016) Diagnosis of the causes of embryonic mortality in agricultural birds: a guide. 2nd ed. Sergiev Posad: VNITIP. (in Russian)

EC (2008) Commission Regulation (EC) No 617/2008 of 27 June 2008 laying down detailed rules for implementing Regulation (EC) No 1234/2007 as regards marketing standards for eggs for hatching and farmyard poultry chicks. Official Journal of the European Union, L 168/5.

Fisinin VI, Stolyar TA, Tardatyan GA, Alexeev FF, Kovatskiy NS (1988) Poultry farming. Rosagropromizdat, Moscow. (in Russian)

Genchev A, Lukanov H (2023) Incubation of agricultural birds based on biological control: Monograph. Academic Publishing House, Trakia University, Stara Zagora. (in Bulgarian)

Hubbard Breeders (2022) Parent stock female. Performance objectives. Available at: https://www.hubbardbreeders.com/media/ps-performance-objectives-hep-enes-imp-20220704-ld.pdf. Accessed 12 October, 2023.

Mailyan ES (2009) Features of incubation of modern crosses of meat poultry. In: V International Veterinary Congress on Poultry Farming, Moscow, pp. 37-48. (in Russian)

Markaryan M, Tsonev T, Likov B (1986) Pathology of avian embryos and veterinary-sanitary measures in hatcheries. Zemizdat, Sofia. (in Bulgarian)

Mymrin IA (1989) Broiler poultry farming. 2nd ed., Rosagropromizdat, Moscow. (in Russian)

Official Gazette (2006) Ordinance 44 from April 20, 2006 on veterinary medical requirements for livestock facilities. Section IV. Veterinary-medical and zoohygienic requirements for hatcheries. Sofia: Official Gazette (NN 41/2006) Available at: https://dv.parliament.bg/DVWeb/showMaterialDV.jsp;jsessionid=3D051C354D99C58FA71A76A3FEE3D112?idMat=196747. Accessed 13 October, 2023.

Orlov MV (1987) Biological control in incubation. Rosselkhozizdat, Moscow. (in Russian)

Peñuela AS, Hernandez AV (2018) Characterization of embryonic mortality in broilers. Revista MVZ Córdoba 23(1): 6500-6513. doi: https://doi.org/10.21897/rmvz.1245.

Pizzari T (2017) Optimising fertility in British broiler breeder flocks - BBSRC Impact 7: 86-88. Doi: https://doi.org/10.21820/23987073.2017.7.86.

Tullet S (2009) Ross Tech. Investigating Hatchery Practice. Aviagen. Available at: https://en.aviagen.com/assets/Tech_Center/Ross_Tech_Articles/RossTechInvestigatingHatcheryPractice.pdf. Accessed 05 December, 2023.

Yassin H, Velthuis AGJ, Boerjan M, Riel J, Huirne RBM (2008) Field study on broiler eggs hatchability. Poultry Science 87(11): 2408-2417. doi: https://doi.org/10.3382/ps.2007-00515.

Yousaf A, Jabbar A, Shahnawaz R, Jamil T, Hassain A, Rais M (2018) Effect of hatch window upon intestinal development chick quality post hatch performance according to Ross-308 broiler breeder age. Journal of Dairy Veterinary & Animal Research 7(6): 293-297. doi: https://doi.org/10.15406/jdvar.2018.07.00229.