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Incubation Conditions Affect Chick Quality and Broiler Performance

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Abstract: Chick quality has gained increasingly more importance for profitable production because of pervading broiler production around the world. There is a critical relationship between the day old chick quality and posthatch broiler performance. The chick quality is affected by incubation conditions during embryonic development stage and after hatching it reflects significantly subsequent performance during rearing period. To estimate of hatchery success, good quality saleable chick percentage is more important than hatchability. Because they are paid based on chick sales. Incubation conditions such as temperature, humidity, ventilation and turning should be provided as optimum standards to meet embryo requirements during development stage. All of these conditions influence embryonic development, chick hatching weight and in this way posthatch growth performance. Recently, some researchers have showed that especially incubation temperature is the most critical factor affecting hatchability, hatchling quality and also subsequent performance. In this review, about temperature, relative humidity, ventilation and turning requirements of embryos during incubation period and their effects on chick quality and broiler performance are discussed.

Key Words: Broiler, Incubation, Temperature, Embryo, Chick quality.

Kuluçka Koşullarının Civciv Kalitesi ve Broiler Performansı Üzerine Etkileri

Özet: Etlik piliç üretiminin dünya genelinde yaygınlaşmasından dolayı, karlı bir üretim için civciv kalitesi giderek önem kazanmaktadır. Civciv kalitesi ile etlik piliç performansı arasında kritik bir ilişki bulunmaktadır. Bir günlük yaşta civciv kalitesi embiyonal gelişim aşamasında sağlanan kuluçka koşullarından etkilemekte ve çıkış sonrasında bu durum yetiştirme dönemindeki performansa yansımaktadır. Kuluçka başarısının değerlendirilmesinde, satılabilir civciv oranı çıkış gücüne göre önemlidir, çünkü kuluçkahaneler satılan civciv sayısına göre kazanç sağlamaktadırlar. Sıcaklık, nem, havalandırma ve cevirme gibi kuluçka koşulları kuluçka boyunca embriyonun ihtiyaçlarını karşılayacak optimum seviyede sağlanmalıdır. Bu koşulların her biri embriyonik gelişimi, civciv çıkış ağırlığını ve dolayısıyla etlik piliç performansını etkilemektedir. Son zamanlarda, özellikle kuluçka sıcaklığının en önemli kuluçka koşulu olduğu ve kuluçka sonuçlarını, civciv kalitesini ve çıkış sonrası

performansı etkilediği bildirilmektedir. Bu derlemede, kuluçkada embriyonun sıcaklık, nem, havalandırma ve döndürme gereksinimleri ile bu koşulların civciv kalitesi ve etlik piliç performansı üzerine etkileri hakkında bilgi verilmiştir.

Anahtar Sözcükler: Etlik piliç, Kuluçka, Sıcaklık, Embriyo, Civciv Kalitesi.

Introduction

In recent years, broiler production has shown a rapid development all over the world, especially in developing countries (Anonymous, 2007a; 2007b). Broiler production system includes many sub-sectors such as broiler breeders and hatching eggs production, hatchery and incubation management, feed production, medicine and vaccine production, poultry house and hatchery equipments, broiler rearing and slaughterhouse.

In broiler production, profitable producing is largely depend on obtaining good quality and healthy hatching eggs. There are many factors affecting hatching egg quality such as, genetic, nutrition of breeders, flock age, diseases, equipments, egg hangling, transport and storage. Today, breeder companies have to control egg production respecting these factors and apply optimum management standards. The relationship between incubation and rearing period has gained more importance by using high yield strains. While broilers reached to 2000 g live weight in 50 days in 1984, this period reduced to 39 days for the same live weight in 2004. Although, lifespan of a broiler with incubation period was approximately 71 days in the past, it was reduced to 60 days in 2004. The rate of time in incubator to total lifespan was increased from 30% to 35% (Boerjan, 2007a; Kampschöer, 2007). When considering these rates, the incubation period has gained increasingly importance. Incubation conditions affect organs, immune system and embryo development, so incubation has an influence on chick quality and broiler performance (Hill, 2000). Therefore, in broiler production, one of the most important stage is incubation management and hatcheries. To achieve maximum hatchability and product quality, healthy and uniform chicks depend on hatching egg quality and optimum incubation conditions. The incubation conditions that should be considered are temperature, humidity, ventilation and turning (Boerjan, 2007a; 2007b).

Requirements of developing embryo such as temperature, relative humidity, ventilation and turning vary during the embryonic development stages. During the early stage of embryonic development, these conditions have effects on organ development, yolk sac utilization and absorption, hatchling quality, embryonic and post hatch early mortality. Hence, knowing well probable effects of incubation conditions and manipulating hatchery practices are very important issues for hactheries.

Incubation Temperature

Incubation temperature is one the most critical factors and the optimum temprature is 37.5-37.7˚C during the development stage and 36.1-37.2˚C during hatching period (Decuypere et al., 2001; Meijerhof, 2009). In the word of more specialized, egg shell temperature affects embryo development and chick quality (Lourens, 2003). The egg shell temperature is an indicator of embryo temperature and it is affected by breeder age, embryonic development stage, heat production by embryo, heat transfer between egg and

envrionment, air temperature in seter and hatcher, air velocity and relative humidity (Meijerhof and Van Beek, 1993, Tona et al., 2004; Lourens et al., 2006; Hamidu et al., 2007; Molenaar et al., 2010).

In large scale hatcheries, during the second stage of incubation period especially after 9^{th} day of incubation, optimum temperatures ranges could not be achieved because of excessive heat production by developing embryos (Nichellmann et al., 1998; Lourens et al., 2007; Meijerhof, 2009). It suppresses heart, crop, gizzard, liver, intestine development and also yolk sac absorption. Embryos with high growing rate are sensitive to temperature fluctuations. Small deviations from optimum ranges have negative effects on hatchability and hatchling quality (Taylor, 2000; Molenaar et al., 2010). In case of providing optimum temperatures, yolk sac is absorbed exactly by embryos, navel of chicks is closed well, thus the number of good quality chicks increases and early stage chick mortality originating from uncovered navel or yolk sac and *E. coli* infections can be reduced (Meijerhof, 2003).

Fluctuations in egg shell temperature results in economic losses in broiler production with negative effects on posthatch performance and slaughter yield (Wilson, 1991; Lourens and Van Middelkoop, 2000), because of the regressive impacts on organ development (Shafey, 2004) and chick growth perfomance (Michels et al., 1974; Decuypere, 1979; Geers et al., 1983).

In higher incubation temperatures, chicks hatch earlier and the navel problems and organ abnormalities could occur more than optimum temperatures. Deeming (2000) reported that higher incubation temperatures increase oxygen requirements of embryos. By much more burning of oxygen, waste heat production and also eggshell temperature show an increase (Lourens, 2003). As a result of this, growth rate is deteriorated, utilization of albumen proteins is repressed and embryo goes under stress. At hatching, higher late term embryonic mortalities, lower hatchability, worse quality of chicks and post-hatch early period chick mortalities could be occured (Deeming, 2000; Lourens et al., 2005; 2007). Deeming (2000) also reported that lower incubation temperatures result in chick death in pip stages. It causes longer incubation period and delayed hatching. Additionaly, abnormal incubation temperatures induce twist toes and this abnormality affects negatively broiler performance in later.

Lately, the effects of different incubation temperatures in a certain stage on embryonic development, chick quality and broiler performance have been investigated by different researchers. Joseph et al. (2006) compared lower temperature (36.6 ˚C) to control (38.1 ˚C) from 1^{st} day to 10^{th} day of incubation and found lower hatchability and rate of saleable chicks in lower temperature treatment than control. Hatchability of total eggs and rate of saleable chicks were found as 87% and 81% in lower temperature treatment, 91% and 87% in control. In the second part of this research, Joseph et al. (2006) investigated that the effects of high incubation temperature (39.4 ˚C) in the same period. It was found that higher temperatures had an increasing effect on hatchability and found as 90% and 88% in control. However it had similar effects on rate of saleable chicks in control (88%) due to higher number of cull and abnormal chicks in higher temperature treatment than control. They also found that while lower temperature during development stage resulted in higher chick hatching weight and shorter chick length, higher temperature during hatching period resulted in lower chick hatching weight, but similar chick length compared to control.

In another study, Hulet et al. (2007) investigated that the effects of low (37.5˚C), control (38.6 ˚C) and high (39.7 ˚C) temperatures during hatching stage of incubation on broiler performance. As a result, they found that differences in chick hatching weight reflected the final broiler weight. The highest chick hatching weight was found in high temperature group as 43.1 g. In low temperature and control group, hatching weight was determined as 41.1 g and 42.2 g. At the end of rearing period, higher final broiler weight was found in control (2263.3 g) than others (low: 2213.8 g, high: 2165.7 g). Also, there were no significant differences for carcass weight and carcass yield among treatment groups.

Suboptimal incubation conditions also cause deficiencies in development during embryonic stage and in broiler growth performonce during rearing period (Meijerhof, 2003). Hill (2002) reported that optimum incubation temperature is required for competence development of organs and growth, if not, it supresses development, growth and survival rate. Wineland et al. (2000a, 2000b) emphasized that heart is one of the most affected organs by suboptimal eggshell temperatures and it causes changes in relative heart weight at hatch. It results in supression of cardiovascular system during embryonic development. As a result of this, a metabolic disorder called ascites, induced by abnormal incubation temperatures, occurs especially during 5^{th} and 6^{th} weeks of rearing and causes serious economic losses (Coleman ve Coleman, 1991).

Humidity

The other important factor affecting chick quality and incubation results is relative humidity. Lundy (1969) reported that optimum relative humidity could be between 50-60% for optimum incubation results. During the incubation, optimum egg weight loss should be approximately 12-14% (Ar and Rahn, 1980). The egg weight loss between 6.5-14% until internal pip stage is too important to ensure an adequte air cell size and to begin lung respiration (Molenaar et al., 2010). Varios factors like temperature within setter, relative humidity, egg shell quality and egg weight influence egg weight loss. While inadequate egg weight loss during embryonic development causes oedema in chicks, excessive egg loss weight results in dehydration and also higher number of small and cull chicks (Lapao et al., 1999; Collins, 2000; Molenaar et al., 2010; Taylor, 2000). According to Taylor (2000), inadequate egg loss weight causes increment of egg albumen, higher percentage of late term embryonic mortality, the higher number of chicks with uncovered navel and red hocks.

During incubation, in lower humidity levels, hatching chicks could be small, dehydrated and sticky (Deeming, 2000). Uncovered navels is one of the most common problems in higher relative humidity levels. It inhibits utilisation of yolk sac, induces yolk sac infections, increases first week chick mortalities.

Chick hatching weight is an indicator of chick quality and it depends on egg weight and also egg weight loss during incubation. The effects of relative humidity levels on chick quality and incubation results have been investigated by some researchers. Bruzual et al. (2000) searched the effects of three different relative humidity as 43%, 53% and 63%. They found the highest hatchability of fertile eggs as 89.1% in 53% relative humidity group and the highest chick hatching weight in 63% relative humidity group. In 63% relative humidity groups, late term embryonic mortalities was found significantly higher than other groups. It

was explained that during late term of incubation, the oxygen requirements of embryos increased, accordingly increasing of water vapor and decreasing of oxygen partial pressure in seter. Similarly, Hamdy et al. (1991) practised two different relative humidity as 45% and 55%. As a result, they found that higher humidity levels cause an increase in chick hatching weight.

Ventilation

Ventilation is needed for providing oxygen in incubator, removing out carbondioxide from incubator, controlling oxygen and carbondioxide level in incubator and preventing improper temperature and gas concentration by air circulation. During incubation period, an egg with avarage egg weight of 60 g consumes approximately 6 L oxygen, exudes 4.5 L carbondioxide and 11 L water vapor (Taylor, 2000).

Embryo's sensitivity to carbondioxide levels changes with embryonic age. Between 1^{st} and 4^{th} days of incubation, the carbondioxide level increases up to 1% without affecting hatchability (Taylor et al., 1956). Especially after 4^{th} days of incubation, embryos show more tolerance against higher concentration of carbondioxide due to functions of their respiratory system (Taylor and Kreutziger, 1965). Deeming (2000) reported that inadequate ventilation in setter or hatcher and in rooms results in liquid accumulation in embryos because of lower oxygen and higher carbondioxide levels. The acceptable range of carbondioxide level in multi-stage setter is approximately 0.1-0.4%, but in hatchers the carbondioxide level as 0.5-0.8% is restrictive for chicks survival rate (Decuypere et al., 2001). Carbondioxide concentration in the incubators depends on number of the fertile eggs and ventilation rate (Molenaar et al., 2010). During hatching period, the higher carbondioxide level forces embryo hatching early so it affects heart and lung maturation and also chick quality negatively (Coleman and Coleman, 1991). The effects of high concentration of carbondioxide level on chick quality and broiler performance is stil unclear so more research is required to investigate the probable effects of unsufficient ventilation during different embryonic development stages.

Turning

During early embryonic development term, turning is required to prevent adhering embryo to eggshell membrane, to inhibit arising incubation temperature inside setter at a certain location, to provide development of corio-allantois sac that is functional for embryo nutrition and respiration, to balance utilization relationship between albumen and yolk sac and to ensure formation of extra-embryonic membranes during the first 18 days of incubation (Deeming, 1999). Additionally, turning of eggs is necessary to avoid malposition (Deeming, 1989). Hatching eggs are placed on incubator with the blunt point and air cell upwards at a 45 degree angle (Preez, 2007). While, Deeming et al. (1987) and Deeming (1989) emphasized that the most critical period of turning procedure is between 3^{rd} and 7^{th} days of incubation, Wilson (1991) reported that there are three critical period for turning as 1^{st}-3^{rd} days, 4^{th}-7^{th} days and 7^{th}-17^{th} days of incubation.

Wilson (1991) also informed that maximum hatchability could be achieved with 96 times turning per day, but 24 times turning per day is more practical than other treatment. It was found that while the frequency of turning increases, the first week weight of chicks

obtained from older broiler breeders reduces (Tona et al., 2002). During incubation, in the absence of turning procedure, embryo adheres to internal egg shell membranes, embryonic malpositions occur, growth of vasculose area decelerates, albumen, yolk sac utilization and oxygen changing reduce. Additionaly, it results in reduction in hatchability and these wet chicks hatch later (Deeming, 2000).

Elibol and Brake (2003) found that maximum hatchability of total eggs was observed in 96 times turning per day than 24 and 48 times turning. While the effects of turning frequency on early and mid term embryonic mortalities insignificant, it was found to be significant for late term embryonic mortalities and observed as higher in 24 times turning per day. The effects of turning frequency on chick quality and broiler performance is stil unclear so more research is required to evaluate the probable effects of turning.

Conclusion

In conclusion, it is confirmed by many studies that variation of 1 g in broiler chick hatching weight reflects to slaughter weight as 50-100 g losses. In field conditions, because of large scale broiler production, performance criterions like final live weight, live weight gain, feed conversion rate and mortality rate are too important for producers and farmers. Hence, the first stage of successful and profitable broiler production depends on accomplished hatchery management and good quality and healthy chick production. In hatcheries, the effects of four fundamental incubation conditions, temperature, humidity, ventilation and turning on embryo development, chick quality and incubation results must be checked and controlled carefully. After hatching, the first week performance of the chicks on farms, like first week live weight, live weight gain, feed conversion rate and mortality rate, are considered with incubation results, thus it can be possible to estimate of the effects of incubation conditions on the broiler performance.

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