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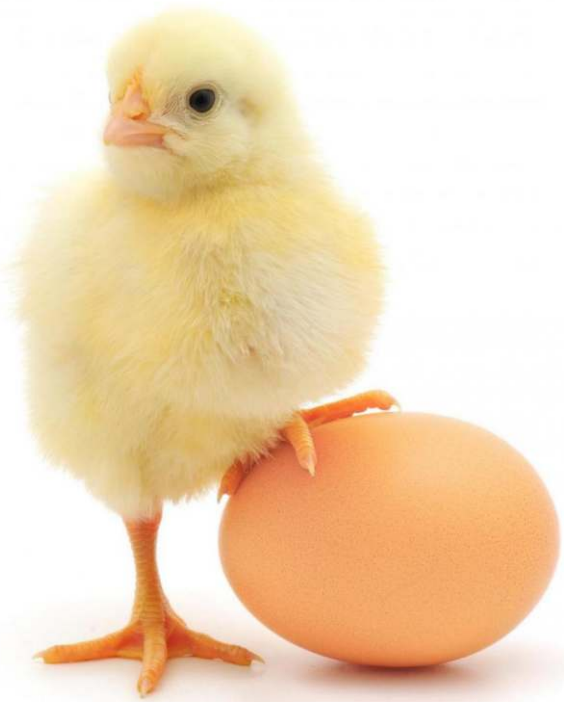

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Review of the Factors That Influence Egg Fertility and Hatchabilty in Poultry

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Abstract: Poultry production at all scales of operation is wholly dependent on the supply of day-old chicks. Fertility and hatchability are two major parameters that highly influence the supply of day-old chicks. Fertility refers to the percentage of incubated eggs that are fertile while hatchability is the percentage of fertile eggs that hatch. It is therefore important to understand the factors that influence fertility and hatchability of eggs. For the hatchability traits, breed has little effect on hatchability of poultry eggs, although light breeds have been reported to have higher fertility and hatchability. The diet of breeder poultry should be adequate in both quality and quantity to meet the recommended levels set out in the feed standards for the category. The most influential egg parameters that influence hatchability are: weight, shell thickness and porosity, shape index (described as maximum breadth to length ratio) and the consistency of the contents. Heat stress reduces the external and internal egg qualities. Heat stress affects all phases of semen production in breeder cocks. Hatchability for small eggs is lower compared to that of medium and large eggs. There are many factors contributing to the failure of a fertile egg to hatch which include lethal genes, insufficient nutrients in the egg and exposure to conditions that do not meet the needs of the developing embryo. Breeder factors that affect hatchability include strain, health, nutrition and age of the flock, egg size, weight and quality, egg storage duration and conditions. The optimum temperature range for poultry is 12-26°C. Fertile eggs should not be stored for more than 10-14 days, after 14 days of storage; hatchability begins to decline significantly. The position (large end up or vice versa) of egg storage influences hatchability. Eggs stored with the small end up have higher hatchability as compared to the large end up. Incubation of fertile eggs can be done naturally by a broody hen or in an incubator. The broody hen provides the fertile eggs with optimum environmental conditions (temperature, egg turning and humidity) to stimulate embryonic development until hatching. The incubator is a simulated artificial design that mimics the broody hen's role of providing fertile eggs with optimum environmental conditions (temperature, egg turning and humidity) to stimulate embryonic development until hatching. A constant incubation temperature of 37.8°C is the thermal homeostasis in the chick embryo and gives the best embryo development and hatchability. Mortality is seen if the temperature drops below 35.6°C or rises above 39.4°C for a number of hours. Egg turning during incubation is critical for successful hatching and influences hatchability. No turning of eggs during incubation results in low hatchability and delays hatch by a few days.

Key words: Poultry, eggs, fertility, hatchability

INTRODUCTION

Poultry production is gaining popularity in the developing countries due to its role in bridging the protein malnutrition, economic empowerment of the resource poor segment of the society and also fits well in the farming systems commonly practiced. Poultry production is practiced at levels ranging from subsistence to large scale commercial operations. The supply of day-old chicks is very important for the success of the poultry production chain. Commercial operations depend on hatcheries for the supply of day-old chicks while the subsistence farmers hatch their chicks by natural incubation. Fertility and hatchability are major parameters of reproductive performance which are most sensitive to environmental and genetic influences (Stromberg, 1975). Fertility refers to the percentage of incubated eggs that are fertile while hatchability is the percentage of fertile eggs that hatch. Fertility and hatchability are major parameters of reproductive performance which are most sensitive to environmental and genetic influences (Stromberg, 1975). Heritability estimates for fertility and hatchability in chickens range from 0.06-0.13 (Sapp *et al*., 2004), this indicates that the non-genetic factors have a higher influence on these traits. Fertility refers to the percentage of incubated eggs that are fertile while hatchability is the percentage of fertile eggs that hatch. Fertility and hatchability are interrelated heritable traits that vary among breed, variety and individuals in a breed or variety. A number of other factors including egg age (Tarongoy *et al*., 1990), storage condition (Brah and Sandhu, 1989), age of flock (Rogue and Soares, 1994; Buhr, 1995), system of husbandry and rearing technology (Weis, 1991), mating system (Gebhardt-Henrich and Mark, 1991), incubation relative humidity and eggs turning angle (Permsak, 1996) have been shown to influence the hatchability of poultry eggs. At each level, it is important to understand the factors that influence egg fertility and hatchability. This paper reviews the factors that influence fertility and hatchability in poultry eggs.

Nutritional factors: The diet of breeder poultry should be adequate in both quality and quantity to meet the recommended levels set out in the feed standards for the category. In the management of breeder poultry, feed is regulated to prevent excessive weight gain, a major cause of poor quality ejaculate and ovulation and at extremes, early ovarian and testicular regression (Brillard, 2007). This will ensure production of good quality and number of eggs and semen. However, new recommendations have been made from time from studies that have been carried out to address handicaps that producers have encountered in the industry. These recommendations cover aspects of certain nutrients, strains/ecotypes that have emerged and feed ingredients. Some of the recommendations have been highlighted. The estimated dietary requirement of protein for laying birds is in the range of 14% to 18% for light and medium sized exotic birds (Harms *et al*., 1966). A study with Saudi Arabian Baladi chickens showed that protein in rearing has no significant effect on fertility and a 12% protein rearing diet is adequate to support high (95.6%) fertility percentages (Alsobayel, 1992). A study with Kenyan indigenous chicken indicated that the dietary crude protein requirement for laying hens is 12% and the maternal dietary protein level has no effect on hatchability (King'ori *et al*., 2010). Local ecotypes/strains have lower dietary protein requirements than exotic birds (Alsobayel, 1992; King'ori *et al*., 2010). Exotic birds have a higher body weight and egg production than indigenous hens. Chamruspollert and Sell (1999) reported no reduction in egg production in chicken fed diets containing any level of Conjugated Linoleic Acid (CLA) in the diet. However, egg weight and yolk decreased in hens offered diets containing more than 5% CLA. The dietary CLA caused adverse effects on hatchability when included in low fat diets. Ayidin *et al*. (2001) showed that a CLA level of 0.5% in the diet caused complete embryonic mortality in fertile chicken eggs. In Japanese quails embryonic mortality occurs depending on the CLA dose and duration of feeding the diets supplemented with CLA (Ayidin and Cook, 2004). Embryonic mortality occurs in eggs because of the modification of fatty acid composition of the egg yolk due to low ratio of unsaturated to saturated fatty acids. Significant changes in the fatty acid composition of egg yolk have adverse side-effects on embryo survival (Donaldson and Fites, 1970). Dietary CLA lead to a lower concentration of monounsaturated fatty acids and higher concentrations of saturated fatty acids in the egg (Park *et al*., 2000; Ayidin and Cook, 2004). Javanka *et al*. (2010) reported improved egg fertility and hatchability of fertile eggs of breeding layers fed brewery by-products. Brewery by-products have linoleic acid content of 4-5% that is responsible for increasing fertility and hatchability of fertilized eggs. Supplementation of laying hen diets with organic selenium (Sel-Plex^{TM}) improves hatchability of fertile eggs (Cantor and Scott, 1974; Davtyan *et al*., 2006; Petrosyan *et al*., 2006; Hanafy *et al*., 2009). Agate *et al*. (2000) reported that organic selenium supplementation of laying hen diets improved the environment of the sperm storage tubules in the hen's oviduct, allowing the sperms to live longer, increasing the length of time the sperms can be stored and increasing the number of sperm holes in the yolk layer. Supplementation of laying hen diets with organic selenium [200 mg Se (Sel-Plex^{TM})/ton diet] increased fertility and hatchability % (Osman *et al*., 2010). Anti-fertility effects of gossypol in females and males of non-ruminant species has been reported (Wu *et al*., 1981; Anderson, 1985; Bender *et al*., 1988). There are marked differences in species susceptibility to gossypol toxicity (Kalla *et al*., 1982; Weinbauer *et al*., 1982; Wong *et al*., 1984) and the anti-fertility effects are dose and time dependent (Saksena and Salmonsen, 1982). Adeyemo *et al*. (2007) reported that cotton seed meal should not replace more than 50% of soya bean meal in breeder cock diets because gossypol suppresses sperm production. Gossypol causes infertility in males due to sperm immobility (due to specific mitochondrial damage in spermatozoa tails) and depressed sperm counts (due to extensive damage to germinal epithelium) (Randels *et al*., 1992). Excess cottonseed in a layer's diet causes them to lay eggs with rubbery or mottled albumen (pink-white disease) because gossypol increases the permeability of the yolk sac membrane, allowing the release of substances, including pigments into egg white. This section emphasizes the need for constant updating of the feed standard recommendations to include new recommendations.

Bird factors: Hen age has an influence on the fertility of eggs (Alsobayel, 1992) and there is a general tendency of fertility to decline with age (Insko *et al*., 1947). Tomhave (1958) reported greater variation in fertile egg percentage in early production cycle than later. Higher fertility has been recorded for light (White Leghorn) when compared with heavy breeds (Barred Plymouth Rock, Rhode Island Red, White Rock and New Hampshire) (Islam *et al*., 2002; Tam and Wong, 1974; Reddy *et al*., 1965). However, Swan (1977) reported higher hatchability percentage with meat strains as compared to egg strains which is in disagreement with the findings reported for the comparison of hatchability of light and heavy breeds. Nwakpu *et al*. (1999) observed that the black Olympia and Hubbard and Nick strains (layer- type chicken) were 20% and 19% (respectively) higher in egg fertility than the investigated Nigerian local chicken.

King'ori (2004) reported lower hatchability of Kenyan local chicken eggs as compared to egg-type chicken hybrids. The findings of these two studies are in disagreement with the findings reported for the comparison of hatchability of light and heavy breeds. For a flock of the same breed difference in fertility has been reported for different batches of eggs (laid at different periods) (Jayarajan, 1992; Islam *et al*., 2002). This difference may be attributed to difference in management practice and environment (Card and Neshim, 1978; Kalita, 1984). Considering the overall hatchability traits, breed has little effect on hatchability of poultry eggs (Islam *et al*., 2002). The optimum cock; hen ratio to ensure production of fertilized eggs should be maintained for the class of poultry under consideration. This ratio ranges from 1 cock for 5-10 hens, depending on the system (intensive or extensive) of production and size (light or heavy) of the breed. Heavy breed hens and the extensive systems require more cocks.

Egg factors: Under normal circumstances, a fertile egg contains all the nutrients necessary for the development of the embryo to hatching. However, there are certain physical and chemical conditions of the egg that may lower or cause no hatchability at all. These may be due to the hen or environmental factors. Eggs usually become fertile about four days after the cock has been introduced to the hens. The physical characteristics of the egg play an important role in the processes of embryo development and successful hatching (Narushin and Romanov, 2002). The most influential egg parameters are: weight, shell thickness and porosity, shape index (described as maximum breadth to length ratio) and the consistency of the contents. The average values of the physical characteristics mostly meet the requirements for the embryo's development. For those eggs, whose parameters do not fall in to the average range, the incubation process is more successful if the shell is thicker than average, the eggs are more pointed rather than round and the contents firm. The results reported for investigations into incubating eggs, whose weights are not within the average values, are contradictory. Both thick shells and firm interiors, which are accepted as being higher than average, lead to an increase in egg weight, which probably results in the more successful hatching of embryos from heavier eggs. Hatchability for small eggs is lower compared to that of medium and large eggs (Asuquo and Okon, 1993). Egg size affects hatchability (Neshiem and Card, 1972; Williamson and Payne, 1978; Mandlekar, 1981). Eggs within 45-56 g weight hatch better than lighter eggs. Mandlekar (1981) reported hatchability of large (51-56 g) and medium eggs (45-50 g) of 88.2 and 84.8%, respectively. These were higher than the hatchability of small eggs (37.5-44 g) reported by Asuquo and Okon (1993). Best hatchability (97%) was reported for medium size eggs (50 g) of Anak broiler eggs (Abiola *et al*., 2008). Large eggs (60 g) had the lowest hatchability (83%). As egg size increases, yolk size increases more than the quantity of albumen (North and Bell, 1990). Ideal hatchability in broilers is achieved when the egg weight ranges between 55-65 g (North and Bell, 1990) and 43-47 g in Kenyan indigenous chicken (King'ori *et al*., 2010). Hatchability for Kenyan local chicken eggs ranged from 66-73% (King'ori *et al*., 2010), which is lower than 80-90% reported for exotic hybrid egg and meat strains (MOALD and M, 1993). Exotic chicken lay large eggs that have been reported to have a higher hatchability than small eggs. There is a positive correlation between egg weight and hatchability (Senapati *et al*., 1996). Gonzalez *et al*. (1999) recommended the setting of average weight eggs for maximum hatchability. There are many factors contributing to the failure of a fertile egg to hatch which include lethal genes, insufficient nutrients in the egg and exposure to conditions that do not meet the needs of the developing embryo. Breeder factors that affect hatchability include strain, health, nutrition and age of the flock, egg size, weight and quality, egg storage duration and conditions (Kirk *et al*., 1980; Wilson, 1991a; 1997; Tona *et al*., 2005). The efficiency of reproduction of broiler breeders decreases with age that is related to the internal egg composition or ratio, larger egg weight, poor shell quality, increased early and late embryo mortality (North and Bell, 1990; Benette, 1992; Vieira and Mora, 1998; Leeson and Summers, 2000; Elibol and Brake, 2003; Tona *et al*., 2004; Joseph and Moran, 2005a) and albumen quality deterioration (Lapao *et al*., 1999; Tona *et al*., 2004) and increase in yolk cholesterol content (Dikmen and Sahan, 2007). There is more infertility and early embryonic mortality in eggs from Ross 308 compared with Cobb 500 broiler strains as the flock ages (Deeming and Middelkoop, 1999; Abudabos, 2010). This could be due to difference in egg weight, egg components like the yolk and albumen percentage, yolk: albumen ratio, shell thickness and incubation time (Suarez *et al*., 1997; Joseph and Moran, 2005b). Older breeder eggs tend to lose more weight in grams but less in percentage when compared to eggs from younger breeders. This is due to the associated increase in egg weight, as larger eggs have less shell area per unit of interior egg weight than smaller eggs (Kirk *et al*., 1980; North and Bell, 1990; Roque and Soares, 1994). Fertility generally declines after a peak (Brotherstone *et al*., 2000) while the effect of age on female breeders is more significant than on male breeders (Brommer and Rattiste, 2008). Factors affecting fertility which originate from the male include sperm quality traits like sperm metabolism, semen concentration, sperm motility and the percentage of abnormal or dead sperm cells (Brammel *et al*., 1996). Fertility factors originating from the female include egg quality, behavioral and physical factors like prevalence of sperm storage tubules (Siegel, 1965). More heat is produced from larger eggs during incubation from older breeders since they have larger embryos (French, 1997). This requires good ventilation for proper cooling.

Incubation/incubator factors: After oviposition, embryonic development in the egg is dependent upon environmental temperature to which the egg is exposed. Incubation is the process of providing fertile eggs with optimum environmental conditions (temperature, egg turning and humidity) to stimulate embryonic development until hatching, which can be natural or artificial.

Natural incubation: The broody hen provides fertile eggs with optimum environmental conditions (temperature, egg turning and humidity) to stimulate embryonic development until hatching. The broody hen chosen for natural incubation should be large (to cover and thus keep more eggs warm), healthy and preferably vaccinated, with a good brooding and mothering record. Signs of broodiness are that the hen stops laying, remains sitting on her eggs, ruffles her feathers, spreads her wings and makes a distinctive clucking sound. A maximum of 14-16 eggs may be brooded in one nest, but hatchability often declines with more than ten eggs, depending on the size of the hen. Feed and water provided in close proximity to the hen will keep her in better condition and reduce embryo damage due to the cooling of the eggs if she has to leave the nest to scavenge for food. The hen rotates the eggs during incubation (Eycleshymer, 1906; Chattock, 1925; Olsen, 1930) about 96 times in 24 h (Olsen, 1930) and keeps the eggs at the correct humidity by splashing water on them from her beak. This is a further reason for providing her with easy access to water. In very dry regions, slightly damp soil can be placed under the nesting material to assist the hen in maintaining the correct humidity (between 60 and 80%). Fertile eggs from other birds are best added under the brooding hen between one and four days after the start of brooding. In Bangladesh, it has been reported that local broody hens will even sit on and hatch a second clutch of eggs, often losing considerable weight in the process (especially if insufficient attention is paid to the provision of food and water). Eggs initially need a very controlled heat input to maintain the optimum temperature of 38°C, because the embryo is microscopic in size. As the embryo grows in size (especially after 18 days), it produces more heat than it requires and may even need cooling. Moisture levels of 60-80% Relative Humidity (increasing during the incubation period) are important to stop excess moisture loss from the egg contents through the porous egg shell and membranes. Factors to consider for successful natural incubation include the following:

- Feed and water should be close to the hen.
- The broody hen should be examined to ensure that she has no external parasites.
- Any eggs stored for incubation should be kept at a temperature between 12 and 14°C, at a high humidity of between 75-85% and stored for no longer than seven days.
- Extra fertile eggs introduced under the hen from elsewhere should be introduced at dusk.
- The eggs should be tested for fertility after one week by holding them up to a bright light (a candling box works best. If there is a dark shape inside the egg (the developing embryo), then it is fertile. A completely clear (translucent) egg is infertile.

Artificial incubation: The modern incubator is a simulated artificial design that mimics the mother-hen's role of providing fertile eggs with optimum environmental conditions (temperature, egg turning and humidity) to stimulate embryonic development until hatching (French, 1997). Hill (2001) and Lourens *et al.* (2005) showed that environmental temperature is the most important factor in incubation efficiency. A constant incubation temperature of 37.8°C is the thermal homeostasis in the chick embryo (Lourens, 2001) and gives the best embryo development and hatchability (Lourens *et al.*, 2007; Wilson, 1991b). Incubator temperature should be maintained between 37.2°C and 37.7°C. The acceptable range is 36-38.9°C. Mortality is seen if the temperature drops below 35.6°C or rises above 39.4°C for a number of hours. If the temperature stays at either extreme for several days, the eggs may not hatch. Overheating is more critical than under heating. Running the incubator at 40.5°C for 15 min will seriously affect the embryos, while running it at 35°C for 3 or 4 h will only slow the chick's metabolic rate. A constant temperature of 38.6°C during incubation initially accelerates embryonic growth, utilization of nutrients and energy from the yolk and albumen reserves, but later decreases embryonic development as a result of limited metabolic process by insufficient exchange of oxygen (Lourens *et al.*, 2005; Rahn *et al.*, 1974). Lourens *et al.* (2005) reported significant embryo mortality and lower hatchability in chicken eggs when they were subjected to an incubation temperature of 38.9°C. Increased embryonic death is due to increased endogenous (metabolic) heat production. An increase in environmental temperature may cause metabolizable energy to be diverted from growth and development to functions involved in homeothermy (Meijerhof and Albers, 1998). An incubator should be operated in a location free from drafts and direct sunlight. It should also be operated for several hours with water placed in a pan to stabilize its internal atmosphere before fertile eggs are set. Although optimal incubation temperature to promote growth of embryos of chicken eggs is 37.5°C some development of the embryo may occur at temperature above 20°C (Proudfoot and Hamilton, 1990). During summer (Temperate areas) and dry season (Tropical areas) the environmental temperature is usually higher than 20°C and hatchability declines. Commercial management of breeder chicken guides recommends that hatching eggs be gathered 4-5 times per day to minimize chances of hens sitting on them hence initiating embryonic development. However, Fasenko *et al.* (1999) reported that hatchability of fertile eggs and embryonic mortality are not affected by gathering fertile eggs two times per day during periods of high environmental temperature. Therefore, there is no advantage of increasing the frequency of egg gathering (Heywang, 1945) thus reducing the labour cost. The hatchability for Meat and Egg type quail eggs is around 84% until 10 days of storage and then this rate decreased significantly (Romao *et al.*, 2008). Both types of quail eggs presented similar weight loss during storage and incubation. The research showed that quail eggs present great hatchability until 10 days of storage and that eggs submitted to storage present a reduced weight loss during incubation. Incubation procedures are important for successful hatching. Store fertile eggs in a clean place at 13-16°C and 70-75% humidity. Never store eggs at temperatures about 24°C and at humidity lower than 40%. These conditions can decrease hatchability dramatically in a very short period of time. Measures aimed at reducing the adverse effects of heat stress on embryo development are of great importance for profitable chick production in the tropics and sub-tropics. Do not store eggs for more than 10-14 days, after 14 days of storage; hatchability begins to decline significantly. Robel (1990) reported that the hatchability of fertile turkey eggs is increased by the injection of exogenous pyridoxine into the eggs following up to 25 days of incubation. The position (large end up or vice versa) of egg storage influences hatchability. Tiwari and Maeda (2005) reported that eggs stored with the small end up had higher hatchability as compared to the large end up. They attributed this to little water loss that could indirectly influence hatchability. In the egg, the embryo is oriented with the head in the larger end of the shell. When the embryo is not oriented correctly, reduced hatchability may occur. In broiler breeder eggs set with the small end up, hatchability was reduced by about 17% (Bauer *et al.*, 1990). Japanese quail eggs incubated with the small side up had lower hatchability and took longer to hatch (Mahdi *et al.*, 2010). Embryos in eggs incubated with small end up are not situated correctly in the egg and are not able to locate the air-cell, especially in the last 2/3 incubation period. It is suggested that the egg can not provide a good environment for the embryo to hatch if it is set with the small end up (Bauer *et al.*, 1990; Wineland, 2007). Egg turning during incubation is important for successful hatching and influences hatchability. No turning of eggs during incubation results in low hatchability and delays hatch by a few days (Van Schalkwyk *et al.*, 2000; Yoshizaki and Saito, 2003). Improved management of eggs during incubation may therefore help to increase the hatchability. The optimum turning frequency is 96 times per day (Wilson, 1991b; Elibol and Brake, 2003), although 24 times per day is accepted as the most practical under commercial circumstances, due to relatively small differences between 24 and 96 times (Freeman and Vince, 1974). There is increased fertile hatchability with increasing turning angle from 20-45° from the vertical (Funk and Forward, 1953) although the difference between 40-45° was small. Byerly and Olsen (1936) reported that egg turning in the third week has little effect on hatchability and Card (1926) observed that eggs turned during the first 6 days hatched nearly as well as those turned throughout incubation. Turning eggs between the 4th and 7th day of incubation gives a hatchability similar to that of eggs turned throughout incubation (New, 1957). However, turning eggs between the 8th and 11th day gives hatchability similar to that of unturned eggs. No turning of eggs causes the allantois to adhere to the yolk sac (Eycleshymer, 1906), embryo to adhere to the shell membranes (Eycleshymer, 1906); delay in the formation of the albumen sac and abnormality in the physical properties of the amniotic and allantoic fluids (Randles and Romanoff, 1950). It is critical to turn the egg in the first week of incubation because at this time a large area of the chorion lies close to the shell membranes and the layer of albumen between the two has been greatly reduced by a loss of fluid from the albumen to the yolk. It is therefore possible to have adhesions between the chorion and shell membranes, unless the shell and its membranes are particularly moved relative to the contents by turning the egg. Some causes and problems associated with poor hatchability are early embryonic death, egg rots, broken yolk, dead-in-shell chicks, prolonged pre-incubation storage, poor breeder nutrition, breeder age, contamination, incubator and hatcher malfunctions (Deeming, 1995; Van Schalkwyk *et al.*, 2000a,b; Chabassi *et al.*, 2004, Hassan *et al.*, 2004; Ipek and Hassan, 2004; Malecki *et al.*, 2005).

Environmental factors: Temperature and photoperiod are the two main factors that influence fertility and hatchability. Male turkeys subjected to a moderately short photoperiod (10.5 L) develop early and persistent development of testes over the entire reproductive season (Brillard, 2007). However, in turkey males as in other poultry species, photo refractory (a physiological response to light stimulation in which birds at first stimulated by increasing and/or long photoperiods become progressively refractory to light stimulation) birds show a progressive decline in plasma LH (Follet and Robinson, 1980) accompanied by a non-reversible testicular regression (Godden and Scanes, 1977; Krueger *et al*., 1977). This lowers semen quality and quantity leading to poor fertility. The optimum temperature range for poultry is 12-26°C. Feed intake in heat-stressed chickens associated with high ambient temperature and relative humidity was reduced by 20%. Heat stress reduces the external and internal egg qualities. High environmental temperature depresses yolk size, albumen consistency and optimum calcium deposit in the egg (Mahmoud *et al*., 1996). The depression is due to an imbalance in calcium-estrogen relationship, lowered Haugh unit of the albumen and decreased voluntary feed intake by the hens. The decrease in voluntary feed intake is attributed to physiological response to heat stress, aimed at reducing excessive endogenous heat generated in the body due to feed metabolism (Ayo *et al*., 2010). Heat stress affects all phases of semen production in breeder cocks (Banks *et al*., 2005). Heat stress depresses reproductive capacity due to a decrease in somniferous epithelial cell differentiation, manifested by decreased semen quality and quantity with time (Edens, 1983; McDaniel *et al*., 1996; Obidi *et al*., 2008). Heat stress has deleterious effects on testicular function through inhibition of intracellular ion exchange (McDaniel *et al*., 1995; 1996). When male broiler breeders were exposed to 32°C, male fertility declined to 42% and *in vivo* sperm-egg penetration declined to 52% compared to values obtained from males that were maintained at 21°C. Semen characteristics like consistency, spermatozoa concentration and semen volume were depressed by environmental temperatures outside the thermo neutral zone (McDaniel *et al*., 1995). The depression in *in vivo* sperm-egg penetration and fertility in heat stressed roosters may be due to a decrease in number of spermatozoa stored in the sperm nest gland in the hen's reproductive tract (Bakst *et al*., 1994; Bakst, 1998; Brillard, 2003). Roosters in natural mating breeding system are known to reduce mating activity and impaired libido due to heat stress, presumably through dehydration and alteration in secretion of sex hormones. Sperm abnormalities like micro-cephalic, bent head, broken mid-piece and cytoplasmic droplets have been reported as contributing factors to heat-stress induced fertility in avian species (Penfold *et al*., 2000).

Conclusion: Success of the poultry industry at small or large scale depends on a regular supply of day-old chicks. The production of day-old chicks is influenced by the fertility and hatchability of the eggs. Fertility and hatchability are traits that influenced by both genetic and environmental factors. Successful production of day-old chicks starts with the proper selection and management of breeding stock, proper post-lay handling of fertile eggs and the correct incubation process.

REFERENCES

Abiola, S.S., O.O. Meshioye, B.O. Oyerinde and M.A. Bamgbose, 2008. Effect of egg size on hatchability of broiler chicks. Arch. Zootech., 57: 83-86.

Abudabos, A., 2010. The effect of broiler breeder strain and parent flock age on hatchability and fertile hatchability. Int. J. Poult. Sci., 9: 231-235.

Adeyemo, G.O., O.G. Longe and D.O. Adejumo, 2007. The reproductive performance of breeder cocks fed cottonseed cake-based diets. Int. J. Poult. Sci., 6: 140-144.

Agate, D.D., E.E. Dea and M.E. Rustard, 2000. Effect of dietary selenium on laying hen fertility as assessed by the periviteline sperm hole assay. Proceedings of the poultry research and production symposium, Alberta poultry research centre, pp: 1-4.

Alsobayel, A.A., 1992. Effect of protein rearing diet and age on fertility and hatchability parameters of Saudi Arabian Baladi chickens. J. King Saudi Univ., 4: 47-54.

Anderson, P.A., 1985. Interactions between proteins and constituents that affect protein quality. In; Digestibility and amino acid availability in cereals and oil seeds (J.W. Finley and D.T. Hopkins, Eds.) Am. Assoc. of cereal chemist. St. Paul, Minnesota, pp: 31-46.

Asuquo, B.O. and B. Okon, 1993. Effects of age and egg size on fertility and hatchability of chicken eggs. E. Afr. Agr. For. J., 59: 79-83.

Ayidin, R. and M.E. Cook, 2004. The effects of dietary conjugated linoleic acid on egg yolk fatty acids and hatchability in Japanese quail. Poult. Sci., 83: 2016-2022.

Ayidin, R., M.W. Pariza and M.E. Cook, 2001. Olive oil prevents the adverse effects of dietary conjugated linolieic acid on chick hatchability and egg quality. J. Nutr., 131: 800-806.

Ayo, J.O., J.A. Obidi and P.I. Rekwot, 2010. Seasonal variation in feed consumption, hen-day, mortality and culls of Bovans Black chickens. Proceedings of the 13th annual conference of the Nigerian society of Animal Production. 14-17th March, pp: 415-418.

Banks, S., S.A. King, D.S. Irvine and P.T.K. Sanders, 2005. Impact of mild scrotal heat stress on DNA integrity in murine spermatozoa. Reproduction, 62: 505-514.

Bakst, M.R., 1998. Structure of the avian oviduct with emphasis on sperm storage in poultry. J. Expt. Zool., 282: 618-626.

Bakst, M.R., G. Wishart and J.P. Brillard, 1994. Oviductal sperm selection, transport and storage in poultry. Poult. Sci. Rev., 5: 117-143.

Bauer, F., S.G. Tullet and H.R. Wilson, 1990. Effects of setting eggs small end up on hatchability and post hatching performance of broilers. Br. Poult. Sci., 31: 715-724.

Bender, H.S., G.K. Sauders and H.P. Misra, 1988. A histopathologic study of the effects of gossypol on the female rat. Contraception, 38: 585.

Benette, C.D., 1992. The influence of shell thickness on hatchability in commercial broiler flocks. J. Appl. Poult. Res., 1: 61-65.

Brah, G.S. and J.S. Sandhu, 1989. Preincubation storage of guinea fowl eggs in cooling cabinet vs. room: Effect on hatchability components. Trop. Agric. (Trinidad and Tobago), 66: 265-268.

Brammel, R.K., C.D. Mcdaniel, J.L. Wilson and B. Howarth, 1996. Age effect of male and female broiler breeders on sperm penetration of periveitelline layer overlying the germinal disc. Poult. Sci., 75: 755-762.

Brillard, J.P., 2003. Practical aspects of fertility in poultry. World's Poult. Sci. J., 59: 441-446.

Brillard, J.P., 2007.Control of fertility in turkeys: the impact of environment, nutrition and artificial insemination technology. Poultry Industry Technical articles.

Brommer, J.E. and K. Rattiste, 2008. Hidden reproductive conflict between mates in a wild bird population. Evolution, 62: 2326-2333.

Brotherstone, S., I.M.S. White and K. Meyer, 2000. Genetic modeling of daily milk yield using orthogonal polynomials and parametric curves. Anim. Sci., 70: 407-415.

Buhr, R.J., 1995. Incubation relative humidity effects on allantoic fluid volume and hatchability. Poult. Sci., 74: 874-884.

Byerly, T.C. and M.W. Olsen, 1936. Certain factors affecting the incidence of malformations among embryo of the domestic fowl. Poult. Sci., 15: 163-168.

Cantor, A.H. and M.L. Scott, 1974. The effect of selenium in the hen's diet on egg production, hatchability and performance of progeny and selenium concentration in eggs. Poult. Sci., 53: 1870-1880.

Card, L.E. and M.C. Neshim, 1978. Poultry Production. 11th Edn. (Reprinted). Lea and Febiger, Philadelphia, New York, pp: 106-113.

Card, L.E., 1926. Incubator eggs turned first six days hatch well. Thirty-ninth Annual Report Illinois Agricultural Experimental station.

Chabassi, C.S., S. Taddei, G. Predari, G. Galvani, F. Ghidini, E. Schiano and S. Cavirani, 2004. Bacteriologic finding in ostrich (*Struthio camelus)* eggs from farms with reproductive failure. Avian Dis., 48: 716-722.

Chamruspollert, M. and J.L. Sell, 1999. Transfer of dietary conjugated linoleic acid to egg yolk of chickens. Poult. Sci., 78: 1138-1150.

Chattock, A.P., 1925. On the physics of incubation. Phil. Trans. B., 213: 397-450.

Davtyan, D., T. Papazyan and L. Nollet, 2006. Dose response of Se added as sodiumselenite or Sel-Plex on sperm quality and breeder productivity. XII European Poultry Conference, Verona, Italy, 10-15 September.

Deeming, D.C. and J.H. Middelkoop, 1999. Effect of strain and flock age on fertility and early embryonic mortality of broiler breeder eggs. Br. Poult. Sci., 40: 522-526.

Deeming, D.C., 1995. Factors affecting hatchability during commercial incubation of ostrich (*Struthio camelus)* eggs. Br. Poult. Sci., 36: 51-65.

Dikmen, B.Y. and U. Sahan, 2007. Correlations between breeder age, egg cholesterol content, blood cholesterol level and hatchability of broiler breeders. Br. Poult. Sci., 48: 98-103.

Donaldson, W.E. and B.L. Fites, 1970. Embryo mortality in quail induced by cyclopropene fatty acids; reduction by maternal diets high in unsaturated fatty acids. J. Nutr., 100: 605-610.

Edens, F.W., 1983. Effects of environmental stressors on male reproduction. Poult. Sci., 62: 1676-1689.

Elibol, O. and J. Brake, 2003. Effect of frequency of turning from three to eleven days of incubation on hatchability of broiler hatching eggs. Poult. Sci., 82: 357-359.

Eycleshymer, A.C., 1906. Some observations and experiments on the natural and artificial incubation of the egg of common fowl. Bio. Bull. Wood's Hole, 12: 360-374.

Fasenko, G.M., J.L. Wilson, F.E. Robinson and R.T. Hardin, 1999. Effects of egg nest holding time and high environmental temperature on prestorage embryonic development, survival and hatchability of broiler breeders. J. Appl. Poult. Res., 8: 488-492.

Follet, B.K. and J.E. Robinson, 1980. Photoperiod and gonadotrophin secretion in birds. Prog. Reprod. Biol., 5: 39-61.

Freeman, B.M. and M.A. Vince, 1974. Development of the avian embryo, Chapman and Hall, London, UK.

French, N.A., 1997. Modelling incubation temperature: The effect of incubator design, embryonic development and egg size. Poult. Sci., 76: 124-133.

Funk, E.M. and J.F. Forward, 1953. The effect of angle of turning eggs during incubation and hatching. Res. Bull.

Gebhardt-Henrich, S.G. and H.L. Mark, 1991. The effect of switching males among caged females on egg production and hatchability in Japanese quail. Poult. Sci., 70: 1845-1847.

Godden, P.M.M. and C.G. Scanes, 1977. Gonadotrophin concentrations during growth and maturation in domestic turkeys. Br. Poult. Sci., 18: 675-685.

Gonzalez, A., D.G. Satterlee, F. Moharer and G.G. Cadd, 1999. Factors affecting ostrich (*Struthio camelus*) eggs hatchability. Poult. Sci., 78: 1257-1262.

Hanafy, M.H., A.M.H. El-Sheikh and E.A. Abdalla, 2009. The effect of organic selenium supplementation on productive and physiological performance in a local strain of chicken. 1. The effect of organic selenium (Sel-Plex™) on productive, reproductive and physiological traits of bandarah local strain. Egypt Poult. Sci., 29: 1061-1084.
Harms, R.H., B.L. Damron and P.W. Waldrop, 1966. Influence of strain or breed upon the protein requirement of laying hens. Poult. Sci., 45: 272-275.
Hassan, S.M., A.A. Siam, M.F. Mady and A.L. Cartwright, 2004. Incubation temperature for ostrich (*Struthio camelus)* eggs. Poult. Sci., 83: 495.
Heywang, B.W., 1945. Gathering and storing hatching eggs during hot weather. Poult. Sci., 24: 434-437.
Hill, 2001. Chick length uniformity profiles as a field measurement of chick quality. Avian Poult. Biol. Rev., 12: 188.
Insko, W.M. Jr., D.G. Steele and E.T. Whiteman, 1947. Reproductive phenomena in ageing hens. Kentucky Agr. Exp. Sta. Bull., 498: 1-23.
Ipek and Hassan, 2004. Effect of breeder age and breeding season on egg production and incubation on farmed ostriches. Br. Poult. Sci., 45: 643-647.
Islam, M.S., M.A.R. Howlinder, F. Kabir and J. Alam, 2002. Comparative assessment of fertility and hatchability Barred Plymouth Rock, White Leghorn, Rhode Island Red and White Rock Hen. Int. J. Poult. Sci., 1: 85-90.
Javanka, L., O. Djuragic and S. Sredanovic, 2010. Use of feed from brewery by-products for breeding layers. Romanian Biotech. Lett., 15: 5559-5565.
Jayarajan, S., 1992. Seasonal variation in fertility and hatchability of chicken eggs. Ind. J. Poult. Sci., 27: 36-39.
Joseph, N.S. and E.T. Moran Jr., 2005a. Effect of age and post emergent holding in the on broiler performance and further processing yield. J. Appl. Poult. Res., 14: 512-520.
Joseph, N.S. and E.T. Moran Jr., 2005b. Characteristics of eggs, embryos and chicks from the broiler hens selected for growth or meat yield. J. Appl. Poult. Res., 14: 275-280.
Kalita, N., 1984. Effect of egg weight on hatchability, Poult. Guide, 22: 95-96.
Kalla, N.R., T.W. Foo and A.R. Seth, 1982. Studies on the male anti-fertility agent gossypol acetic acid on the fertility of male rats. Andrologia, 14: 492.
King'ori, A.M., 2004. The protein and energy requirements of indigenous chickens (*Gallus domestics*) of Kenya. Ph.D thesis. Egerton University, Kenya, pp: 93.
King'ori, A.M., J.K. Tuitoek, H.K. Muiruri and A.M. Wachira, 2010. Effect of dietary protein levels on egg production, hatchability and post-hatch offspring performance of indigenous chickens of Kenya. Int. J. Poult. Sci., 9: 324-329.
Kirk, S., G.C. Emmans, R. Mcdonald and D. Arnot, 1980. Factors affecting the hatchability of eggs from broiler breeders. Br. Poult. Sci., 21: 37-53.
Krueger, K.K.K., J.A. Owen, C.E. Kruegern and T.M. Ferguson, 1977. Effect of feed or light restriction during the growing and breeding cycles on the reproductive performance of broad breasted white turkey males. Poult. Sci., 56: 1566-1574.
Lapao, C., L.T. Gama and M.C. Soares, 1999. Effect of broiler breeder age and length of egg storage on albumen characteristics and hatchability. Poult. Sci., 78: 640-645.
Leeson, S. and J.D. Summers, 2000. Broiler breeder production. University Books, Guelph, Ontario, Canada.
Lourens, A., 2001. The importance of air meteorology in animal production. Int. J. Biomet., 2: 139-156.
Lourens, A., H. Van den Brand, R. Meijerhof and B. Kemp, 2005. Effect of eggshell temperature during incubation and embryo development, hatchability and post-hatch development. Poult. Sci., 84: 914-920.
Lourens, A., H. Van den Brand, M.J.W. Heetkamp, R. Meijerhof and B. Kemp, 2007. Effects of eggshell temperature and oxygen concentration on embryo growth and metabolism during incubation. Poult. Sci., 86: 2194-2199.
Mahdi, B.G., M.S. Naser, L. Alireza and S.A. Ayub, 2010. Effects of setting eggs small end up on hatchability and embryo mortality in Japanese quail (*Cotunix cotunix japonica*). Global Vet., 4: 592-594.
Mahmoud, K.Z., M.M. Beck, S.E. Scheideler, M.F. Froman, K. Anderson and S.D. Kachman, 1996. Acute high environmental temperature and calcium-estrogen relationships in the hen. Poult. Sci., 75: 1555-1562.
Malecki, I.A., J.O. Harbanczuk, C.E. Reed and G.B. Martin, 2005. The ostrich (*Struthio camelus)* blastoderm and embryo development following storage at various temperatures. Br. Poult. Sci., 46: 642-660.
Mandlekar, D.H., 1981. A note on fertility and hatchability and egg weight in boiler chicken. Ind. Poult. Rev., XI: 33-34.
McDaniel, C.D., R.K. Bramwel and B. Hawort, 1995. The male's contribution to broiler breeder heat-induced infertility as determined by sperm-egg penetration and sperm storage within the hen's oviduct. Poult. Sci., 74: 1546-1556.
McDaniel, C.D., R.K. Bramwel, J.C. Wilson and B. Haworth, 1996. Fertility of male and female broiler breeders following exposure to elevated ambient temperature. Poult. Sci., 75: 1029-1033.
Meijerhof, R. and G. Albers, 1998. The influence of incubator conditions on the incidence of ascites. Incubation and fertility group meeting abstract, pp: 119-120.

MOALD and M., 1993. Ministry of Agriculture, Livestock Development and Marketing, Kenya. Animal Production Division, Kenya. Annual Report.

Narushin, V.G. and M.N. Romanov, 2002. Egg physical characteristics and hatchability. World's Poult. Sci. J., 58: 297-303.

Neshiem, M.C. and L.E. Card, 1972. Tropical Agriculture. (4th Edn.) McMillan Press Ltd, pp: 52-58.

New, D.A.T., 1957. A critical period of turning hens' eggs. J. Embryol. Exp. Morph., 5: 293-299.

North, M.O. and D.D. Bell, 1990. Commercial chicken production manual. 4th Edn., AVi, New York.

Nwakpu, P.E., B.I. Odo, S.I. Omeje, M. Akpa and C.C. Edoga, 1999. Hatching performance of three strains of layer-type chicken and their lines. Proceedings of the 26th Annual Conference, NSAP, 21-25 March, 1999, Ilorin.

Obidi, J.A., B.I. Onyeanusi, P.I. Rekwot, J.O. Ayo and T. Dzenda, 2008. Seasonal variation in semen characteristics of Shikabrown breeder cocks. Int. J. Poult. Sci., 7: 1219-1223.

Olsen, M., 1930. Influence of turning and other factors on the hatching power of hens' eggs. Thesis, Iowa State College.

Osman, A.M.R., H.M. Abdel Wahed and M.S. Ragab, 2010. Effect of supplementing laying hens diets with organic selenium on egg production, egg quality, fertility and hatchability. Egypt. Poult. Sci., 30: 893-915.

Park, H.Y., J.M. Storkson, J.M. Ntambi, M.E. Cook, C.J. Sih and M.W. Pariza, 2000. Inhibition of hepatic stearoyl-Coa desaturase activity by trans-10, cis-12 conjugated linoleic acids and its derivatives. Biochim. Biop. Acta, 1486: 285-292.

Penfold, L.M., D.E. Wildt, T.L. Herzog, W. Lynch, L. Ware, S.E. Derrickson and S.I. Monfort, 2000. Seasonal patterns of luteinizing hormone, testosterone and semen quality in Northern Pintail duck. Reprod. Fert. Dev., 12: 229-235.

Permsak, S., 1996. Effect of water spraying and eggs turning angle to efficiency of duck hatchability. Proceedings of the 34th Kasetsart university annual conference, Bangkok (Thailand), 1996, pp: 517, 22-26.

Petrosyan, A., T. Papazyan and L. Nollet, 2006. Administration of Se as Sel-Plex on top of sodiumselenite improves fertility and hatchability of a broiler breeder flock. XII European Poultry Conference, Verona, Italy, 10-14 September.

Proudfoot, F.G. and R.M.G. Hamilton, 1990. Care of hatching egg before incubation. Publication 1573/E Communications Branch, Agriculture Canada, Ottawa, ON, Canada.

Rahn, H., C.V. Paganelli and A. Ar, 1974. The avian egg: Air-cell gas tension, metabolism and incubation time. Resp. Physiol., 22: 297-309.

Randels, R.D., C.C. Chase Jr. and S.Y. Wysc, 1992. Effects of gossypol and cotton seed products on reproduction of mammals. J. Anim. Sci., 70: 1628-1638.

Randles, C.A. and A.L. Romanoff, 1950. Some physical aspects of the amnion and allantois of the developing chick embryo. J. Exp. Zool., 114: 87-101.

Reddy, V.B., D. Subarayudee and P. Varadarajulee, 1965. The effect of breed, pre-incubation storage time and egg weight on hatchability of poultry. Anim. Breed Abstr., 34: 268.

Robel, E.J., 1990. Composition and method for increasing the hatchability of turkey eggs. (Monograph). Agris, 1993-1994.

Roque, L. and M.C. Soares, 1994. Effects of eggshell quality and broiler breeder age on hatchability. Poult. Sci., 73: 1838-1845.

Romao, J.M., T.G.V. Moraes, R.S.C. Teixeira, W.M. Cardoso and C.C. Buxade, 2008. Effect of egg storage length on hatchability and weight loss in incubation of egg and meat type japanese quails. Braz. J. Poult. Sci., 10: 143-147.

Saksena, S.K. and R.A. Salmonsen, 1982. Anti-fertility of gossypol in male hamsters. Fertil. Steril., 37: 686.

Senapati, P.K., K.G. Dask Madal and A.K. Chatterjee, 1996. Relationship between egg weight, shape index, fertility and hatchability of Japanese quail eggs. Environ. Ecol. Stat., 14: 574-577.

Sapp, R.L., R. Rekaya, I. Misztal and T. Wing, 2004. Male and female fertility and hatchability in chickens: A longitudinal mixed model approach. Poult. Sci., 83: 1253-1259.

Siegel, P.B., 1965. Genetics of behavior: Selection for mating ability in chicks. Genetics, 52: 1269-1277.

Stromberg, J., 1975. A Guide to Better Hatching. Stromberg Publ. Co. Iowa, USA, pp: 8-25.

Suarez, M.E., H.R. Wilson, F.B. Mather, C.J. Wilcox and B.N. Mcpherson, 1997. Effect of strain and age of the broiler breeder female on incubation time and chick weight. Poult. Sci., 76: 1029-1036.

Swan, S.E.J., 1977. Fertility and hatchability of meat and egg strains of poultry in Fiji. Poult. Abstr., 3: 425.

Tam, Y.Y. and Y.C. Wong, 1974. Observation on fertility and hatchability of eggs. Poult. Abstr., 3: 216.

Tarongoy, Jr., F. Eduave and E.K. Gemota, 1990. Age as a factor of hatchability. SWUCA-J. Agric. Res. (Philippines), 5: 22-26.

Tiwari, A.K.R. and T. Maeda, 2005. Effects of egg storage position and injection of solutions in stored egg on hatchability in chickens (*Gallus domesticus*) research note. J. Poult. Sci., 42: 356-362.

Tomhave, A.E., 1958. Fertility and hatchability of eggs produced by New Hampshire breeders during their first 365 days production. Poult. Sci., 37: 27-29.

Tona, K., O. Onagbesan, B. De Ketelaere, E. Decupere and V. Bruggeman, 2004. 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., 13: 10-18.

Tona, K., V. Bruggeman, O. Onagbesana, F. Bamelis, M. Gbeasor, K. Mertens and E. Decuypere, 2005. Day-old chick quality: Relationship to hatching egg quality, adequate incubation practice and prediction of broiler performance. Avian Poult. Biol. Rev., 16: 109-119.

Van Schalkwyk, S.J., S.W.P. Cloete, C.R. Brown and Z. Brand, 2000. Hatching success of ostrich eggs in relation to setting, turning and angle of rotation. Br. Poult. Sci., 41: 46-52.

Vieira, S.L. and T. Mora Jr., 1998. Eggs and chicks from broiler breeders of extremely different age. J. Appl. Poult. Res., 7: 372-376.

Weinbauer, G.F., E. Rovan and J. Frick, 1982. Anti-fertility efficacy of gossypol acetic acid in male rats. Andrologia, 14: 270.

Weis, J., 1991. Analysis of fertility, hatchability and egg quality indices in reproduction breeding of guinea fowls. Acta Zootechnica Universitatis Agriculturae (CSFR). Number 47 pp: 5-15.

Wilson, H.R., 1991a. Interrelationships of egg size, chick size, post hatching growth and hatchability. Worlds' Poult. Sci. J., 47: 5-20.

Wilson, H.R., 1991b. Physiological requirements of the developing embryo: Temperature and turning in avian incubation. S.G. Tullet, Ed. Butterworth-Heinemann, London, UK., pp: 145-156.

Wilson, H.R., 1997. Effects of maternal nutrition on hatchability. Poult. Sci., 76: 134-143.

Williamson, G. and W.J.A. Payne, 1978. An Introduction to Animal Husbandry in the Tropics. 3rd Edn., Longman Inc. New York, pp: 1266-1274.

Wineland, M., 2007. The importance of traying eggs with the large end up. Extension paper, college of Agriculture and Life science North Carolina State University, No: 4/96, PS Facts #20. Online:http://www.cos.ncsu.edu/depts./poulsci/tech_manuals/traying_eggs.html.

Wong, P.Y.D., J.P. Qiu and W.O. Fu, 1984. Gossypol does not affect testicular fluid secretion in rats. Contraception, 29: 471.

Wu, Y.M., S.C. Chappel and G.L. Flickinger, 1981. Effects of gossypol on pituitary-ovarian endocrine function, ovulation and fertility in female hamsters. Contraception, 24: 259.

Yoshizaki, N. and H. Saito, 2003. Changes in shell membranes during the development of quail embryos. Poult. Sci., 81: 246-251.