IDENTIFYING BROILER MEAT PRODUCTION CHALLENGES IN GHANA:

FOCUSING ON HATCHERY PERFORMANCE

BY:

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(B.ED INTEGRATED SCIENCE)

A DISSERTATION SUBMITTED TO THE SCHOOL OF GRADUATED STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF PHILOSOPHY ANIMAL BREEDING AND GENETICS

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DEDICATION

This project is dedicated to my parents the Late Prof. Thomas Kwadwo Djang-Fordjour and Ms. Comfort Esi Appiah for their unconditional love they show me and all the sweet people who have contributed to my life.

DECLARATION

I, Helen Djang- Fordjour declare that this work was done by me under the supervision of Dr J.A. Hamidu. The work has not been published in part or whole elsewhere while references made have appropriately been cited.

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ABSTRACT

The hatchery and hatching egg industry has performed minimally in Ghana over the past 20 years. As a result importation of day old chicks in Ghana has increased considerably. The objective of the current study was to provide inventory of actively operating hatcheries in Ghana and identify common incubation procedures and factors in selected hatcheries that may be affecting poultry embryo development, hatchability, chick quality and broiler growth. Three studies were carried out. In Experiment 1, a survey was carried out on all active hatcheries to take inventory of human resource strength and qualification, hatchery output, capacity of operation, availability of parent stock, common hatchery practices put in place to increased chick quality, day old chick production and market outlets, rates of chick mortality, distance of hatcheries from breeding farms, audit of hatcheries that imported eggs to hatch, type of incubators used and incubation system applied and whether hatcheries provide any follow-up on farms that take chicks from them. In Experiment 2, common incubation procedure and factors that may be affecting poultry embryo development, hatchability, chick quality and broiler growth in 2 selected hatcheries (Hatcheries A and B) were studied which represented trial 1 and trial 2. Hatchery performance were compared based on the age of parents flocks and days in which eggs were stored prior to incubation. In each trial, eggs were weighed and stored before incubation. Upon hatching 120 day old chicks were transported to the Microbiology laboratory at the Department of Animal Science, KNUST for dissection. Parameters measured included were eggs weight before and after storage, chick quality parameters and incubation parameter. All data were either transformed or analysed statistically using the Generalized Linear Model Procedure of SAS 9.4 at $p<0.05$. In Experiment 1, the results showed that there were 9 hatcheries in Ghana operating actively as at the year 2013 in hatching broiler or layer chicks or both. Out of this, 7 responded to the survey questions. Only two of these hatcheries were operating 60 and 68% of their full capacity (38,000 and 115,200 eggs respectively). The type

of incubators used included ChickMaster, Buckeye, Asefac, Petersime, Westing and Beckier. All the hatcheries were operating with the multistage incubation system(different ages of eggs are incubated at the same time in one machine). Only one hatchery had a single stage incubator (one incubator is loaded in one go with one type of egg. The incubator is empty after transfer). Three of the 7 hatcheries provided basic training for all staff and additional three provided training for about 40 to 70 % of their staff. All these training were on the job. Three of the hatcheries had their own parent stock, while the rest buy eggs or depended on farmers contracting them to hatch. Major hatchability challenges reported were dead in shells, unsealed navels, twisted beak, wet chicks, and blind chicks among others.

In Trials 1 and 2 the results showed significance difference in chick length, shank length and proportion of yolk free body mass and residual yolk sac between different maternal flock ages and storage treatments irrespective of the kind of hatchery. There was variation in the incubation conditions from one hatchery to other. The temperature and relative humidity in the egg storage rooms were 16^{o}C and 75% in hatchery A compared to 20^{o}C and 38% in hatchery B. These variations can result in different chick qualities and which is likely to be lower in hatchery B some of these qualities included twisted beak, wet chicks, unsealed navel, blind chicks. The variabilities in incubation techniques resulting in varied chick quality parameters could be due to lack of technical understanding of incubation and therefore need to be addressed.

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CHAPTER ONE

1.0 INTRODUCTION

The most populous livestock species are chickens and farmers easily keep them either to sell or for their own use (Perry *et al*., 2002; Moreki *et al*., 2010). Therefore, concentrating on poultry rearing could affect the lives of farmers in a good way. In addition, so that their livelihood and household dependency on poultry nutrients could improve on the quality of farmers nutrition and income, especially in developing countries. Ghana's Gross Domestic Product from agriculture in 2014 was 19.9% (GSS, 2014). This was a reduction from almost the 40% recorded in 2009 which placed the country as largely based on an agrarian economy. Currently the contribution of livestock in Ghana including poultry in 2014 is 1.3% indicating a further reduction from 2% in 2009 (GSS, 2014). Ghana's GDP continues to decline especially, from contribution in animal production, which is derived from animals such as cattle, sheep, goats, pigs, chickens, turkeys, ducks, geese and guinea fowls, goats, sheep and cattle. The situation reveals Ghana's overdependence on imports instead of producing her own products. A 2013 records showed that Ghana imported over 4.2 million day old chicks annually, mostly because of the need for higher quality chicks day old (Sumberg and Thompson, 2013; Ghana Poultry Report, GPRA, 2013).

In Ghana poultry production is saddled with a lot of challenges (Adei and Asante, 2012). Feed contributes up to about 80% of production cost and is described as the major factor affecting poultry farm operations (Benabdeljelil *et al*., 2001). Sadly enough good and healthy day old chicks and conditions and availability of hatchery outlets coupled with institutional support needed for existing hatcheries to hatch quality chicks to start up production are often lacking. However, the total sidelining of this aspect of poultry production does not take cognizance of the increased number of day old chicks that are imported into Ghana annually. Anecdotal data show that one poultry producer in Kumasi imports up to 40,000 to 50,000 breeder day old chicks per year from Germany at a cost of over $7 USD per chick for parent stock excluding port clearing, handling and Veterinary certification charges before the chicks reach the farms(Aboagye Poku, 2016-personal communication). The situation indeed shows that quality day old chicks are required for the successful take off of the poultry operation besides and not necessarily feed which claims to be the most important factor responsible for the declining of the Ghana poultry industry. Therefore, there is a new call for a full inventory of hatcheries in Ghana and potential production of quality day old chicks to support existing poultry farms and ensure production sustainability (Djang-Fordjour *et al*., 2014).

Previously, it has been reported that, seven hatcheries in Ghana concentrated on producing chicks for farmers to rear for commercial purposes irrespective of the breed (Aning, 2006). But checks with the farms and poultry associations in Ghana as part of the current study showed that majority of these hatcheries have been out of business. In addition, the ones existing produced only 60 percent of their capacity because of less demand, besides most of these hatcheries are for layer chicks. This continues to be a major setback for the broiler production industry. According to the report, as many as three hatcheries have their own breeding stock for both breeds of broiler and layers. The rest of the hatcheries imported hatchable eggs directly from Europe or from neighbouring countries (GPRA, 2013). This is further worsened by the importation of cheap broiler meat, often wings and thighs of chickens. The problem of quality day old chicks' production may persist because of the lack of hatchery training and programs available in Ghana to teach good incubation practices. In addition, research into tropical conditions affecting incubation practices and day old chicks' production need to be embraced by all stakeholders in the livestock industry.

1.1 General Objectives

The objectives of this study were to assessing the performance of hatcheries in operation in Ghana and identifying common practices in selected hatcheries that could be enhanced to increase production of quality day-old-chicks.

1.2 Specific Objectives

1. Conduct an inventory of current hatcheries in Ghana and assess the potential for improvement of incubation and incubation practices.
2. To identify common incubation procedures and factors in selected hatcheries that may be affecting poultry embryo development, hatchability, chick quality and broiler growth.

CHAPTER TWO

2.0 LITERATURE REVIEWS

2.1 History of Challenges of the Ghana Poultry Industry

Poultry production has been one of the focuses of the Government of Ghana since the 1960s because of its potential to improve on the nutrient content of the feed we consume. The Ghanaian economy used to be based mainly on agriculture and accounted for almost 41% of Gross Domestic Product (GDP). At the time, livestock including poultry sector served as a means of safety by providing funds for emergency needs (MOFA/DFID, 2002). Within the agricultural GDP, the animal sector contributed only 7% to the agriculture (FASDEP, 2002) which automatically affected the various operations leading to their production in the various regions in Ghana especially in the middle belt of Ghana (Ashanti and Brong Ahafo Regions).The industry gives a long lasting career to rely on and also form channels for poultry products in Ghana (Aning, 2006). The growth of industry was slower in the 1960s as chicks for raising and farm inputs were not forth coming. This was worsened by consistent outbreak of Newcastle Disease which did not encourage farmers to go into its production. By the 1970s these difficulties were overcome which boosted poultry production. In the early 1980s however, the inflation in

Ghana's economy had a severe effect on farming inputs and thereby causing a decline in production (Aning, 2006). The author reports that even though situation improved by end the 1990s a change in Government policy caused the country to allow import of cheap poultry and poultry products and then asked farmers to pay more on the taxes which were abolished earlier on the imported inputs which previously had contributed to its downfall. Additionally, the successive spread of the Gumboro disease and the annual occurrence of Newcastle also contributed to this decline. The outbreak of the bird flu (H5NI) in parts of Asia, Europe and Africa threatened the local poultry industry in Ghana thus should have been an opportunity to boost poultry(Aning, 2006). Another study has observed that between the 1980s to 1990s Ghana's poultry sector grew into a formidable sector and provided about 95% of its populace with its meat and eggs (Flake and Ashitey, 2008). But beyond that the sector went a downward in the production due to cost (nutrition, labour and equipment) and lack of funds (Flake and Ashitey, 2008).

In 2002, Ghana imported almost 30,000 tonnes of chicken from countries which subsidize its farmers. Within twenty–four months, this figure almost increased to approximately 40,000 tonnes (ISODEC, 2004). The local poultry industry which once took care of Ghana's market needs in 1992, only provided 11% of the market demand needs by 2002.By 2008, the domestic poultry sector provides less than 10% (Kudzodzi, 2008).

Over the last five years, chicken importation into the country cumulatively accounted for almost 75% which represents about 521,291 metric tonnes of meat imports according to Daily Graphic (2014). This meant that there was only 36.5% of locally produced meat which represented 127,038 tonnes within the same period.

2.1.1 The Contribution of the Hatchery Industry in Ghana's Economy

It is reported that there were seven major hatcheries namely Darko (Ashanti), Afariwaa (Greater Accra), Sydal (Greater Accra), Asamoa-Yamoa (Ashanti), Topman (Ashanti), Kranyako (Eastern) and Jehu (Ashanti) in the Country which produce chicks for commercial purposes of both broiler and layers (Ghana Poultry Report Annual, 2013).However most of the hatcheries listed above produced about 60 percent below demand (Ghana Business News (GBN), 2013). However, the demand for layer day old chicks alone is over 80 percent of total capacity in Ghana. It was observed by GBN (2013) that out of these only three of these hatchery companies kept their own parent stocks of layers or broilers mostly of Lohman breeds. The other 'producers' rather import fertile eggs to hatch.

2.2 Breeding Stock

Modern chickens' breeds and now strain were developed by selecting desirable production traits to regain breed production characteristics of poultry at risk in the early mid-20th century (Schrider, 2007). The breeding process begins with parent stock, a group of birds bred for the main purpose of propagation of the next generation Poultry Consultancy (2015). Farmers look for certain characteristics in purebred stocks to take part for a certain purpose or may use of some types of crossbreeds to produce a new type of parent stock with a different or better abilities in an area of endeavour. Generally birds are selected for dual purposes (birds used for both egg and meat) and for singles purposes (birds selected for meat production or egg production). In the process certain information are used by the producers to identify birds that would be good to be retained for breeding stock. These include rate of growth, mature size, egglaying ability, breed type, colour fertility and vigour. Usually the producer will need to retain fewer males than females for breeding stock (Schrider, 2007). Hence the need for strict selection of the males is an important component to a sound breeding program. The main purpose of broilers is to produce meat. Modern broilers meant for commercial purpose were culled from the Cornish crossed or the Cornish-Rocks and are purposely crossed for the use of meat production on commercial base. They were selected grow better and faster (Poultry Consultancy, 2015).

These birds are specifically meant for growing swiftly, convert feed faster to meat and are not the types to involve in excessive activity. This means that birds which are for a single purpose should have the following characteristics in their production excellent growth rate, good skeletal development and resilient. Broilers often reach a maturity weight of 2-2.5 kg dressed weight only eight weeks. They appear white and slightly yellowish colour skin when slaughtered. This type is preferred because it does not have the characteristic 'hair' which other birds have that requires singeing after plucking. Both sexes of broilers are slaughtered for their carcass (Poultry Consultancy, 2015).

According to Addison (2013)**.**, at the beginning of mass poultry production most of the birds sold to be raised were pure forms of broiler breeds. Breeding practices were solely meant for economic purpose of the pure traits. Generally, however a couple or more of breeds were bred to better their efficiency. Eventually, those new hybrids of birds bred for the production of meat produced new synthetic lines (Addison, 2013)**.** Although many true breeds were blended in their production, these new hybrids did not resemble any former breed or variety (Addison, 2013)**.** (Addison, 2013). They were entirely new; many more are being developed regularly (Addison,

2013)**.** Some of the offsprings and strains of chickens used in today's crosses, or used to develop entirely different lines include: Single Comb White Leghorn, Single Comb Rhode Island Red, New Hampshire, White Plymouth Rock, Cornish, Barred Plymouth Rock and Light Sussex (Addison, 2013). There are also local and fancy breeds throughout the world and they are characterized by low performance and are often maintained in small population (Hagan, 2010). The fancy breed as the Cornish Red and the White Rock have been very important contributors to the strains that now produce our modern strains of broiler (Hagan, 2010). If these local breeds are genetically eroded it can lead to the loss of valuable genetic traits in specific characteristics that are at present not wanted in commercial breeding strategies (Ladokun *et al.*, 2008). In light of this, it can be said that it is very important that these breeds are maintained in the future as gene banks because they may contain useful genes that could be exploited commercially (Smith, 1990). According to Hagan(2010), the genetic traits of the local chickens in the tropics are rich and should therefore be used for genetic improvement and diversification to produce a breed adapted to the tropics. According to Aning (2006) the breeds imported and used for commercial production in Ghana were produced internally from previously bred parent flock or from eggs imported from trusted sources. For egg production, the following are used: Shaver Starcross 579, Hisex Brown, ISA Brown, Lohman Brown, Starcross 288 and a locally developed strain Afabird.

When it comes to broiler production the following were used Starbro, Ross1 (UK), Hybro (Holland), Arbor Acres, Cobb (USA) and Hypeco (Holland) and are imported into the country. Breeds such as the Afabro is a locally bred broiler used and they are distributed throughout the country by commercial production farms in the past (Aning, 2006). Upon personal communication with the breeders and the commercial farms involved, these breeds are out of the system due to the collapse of the farms or apparent change of service from poultry to other supposed lucrative services.

2.2.1 Genetic Selection

Different breeds of birds have different genetic makeup which affects egg production, hatchability and chick quality (Al-Bashan and Al-Harbi, 2010). Infertility results in the inability of the eggs to hatch in some case while in other cases the zygote forms but does not develop and therefore dies for a wide variety of reasons (Al-Bashan and Al-Harbi, 2010). In chickens, abnormal position has been estimated to cause 50-55% of mortality in the last 3 days of incubation and 25% of total embryo mortality (Kalita *et al.*, 2013). In naked neck chicken it has been theorized that the higher number of malpositions during late incubation was peculiar to this breed (Dunga *et al.,* 2013). Other researches show that for chicken eggs with easily distinguishable large and small ends they have higher hatchability and a lower incidence of abnormal position than do eggs with indistinguishable ends (rounder shape) (Wilson, 1991). Wilson and Suarez (1993) showed that slight variations in the incidence of malpositions in chicken embryos can be attributed to genetic strain. It is suggested that genes are affected when young birds (pullet) gain some quality (albumen) from their maternal lineage to produce good albumen characteristics (Islam *et al.,* 2001). Egg quality is affected by selection on body weight, even though this effect may differ between experiments. The differences may originate from the breeding lines (Islam *et al.,* 2001). Although selection on egg production could increase yolk content, selection on egg quality traits has shown genetic variation for yolk content and yolk related characters (Minvielle and Oguz, 2002). In selecting birds for breeding, it is important to know the different genetic make-up which affects egg production, hatchability and chick quality (Al-Bashan and Al-Harbi, 2010). Other Parameters such as hatching time, chick quality characteristics, fertility , quality of egg (Tona *et al.,* 2002) first week chick mortality (Beaumont *et al.,* 1997) and eggshell conductance and embryonic metabolism (Hamidu *et al.,* 2007) have reflected difference in genetic strains.

2.2.2 Parent Flock Age.

As breeders age, egg weight increase (Khursid et al., 2003), shell thickness reduces (Peebles *et al.,* 2000) and yolk weight increases (Suarez *et al.,* 1997). Eggs laid by young breeder stocks have better albumen quality and hence produces better chicks (Tona *et al.,* 2004). Old breeder stocks produce a large number of heavier chicks (Suarez *et al.,* 1997; O'Dea *et al.,* 2004).

However, the number of low quality chicks or parent increases in older breeder flocks (Tona *et al.*, 2001, 2004). An experiment that was conducted to determine the effect of flock age on hatchability and embryonic mortality concluded that hatchability and embryonic mortality increased with increasing flock age with its peak at about 45 weeks before its decline. This is attributed to the sexual maturity of the birds. Eggs produced during early periods have low quality i.e. defective eggs or soft shells. However production at later stages birds are uneconomical and are mostly killed (Al-Bashan and Al –Harbi, 2010). A positive negative effect of flock age on yolk weight has been reported (Suarez *et al.*, 1997).This implies that as flock age increases, weight of yolk can increase twice as much in the egg from older flocks compared to the yolk presented in a very young flock egg. Egg size was found to be positively correlated with age and as flock age increases the size of the egg also increases (Amankwah, 2013).

2.2.3 Breeder Nutrition

For a chick to reach its full genetic potential as a broiler chicken, it is important that it has the right start in life (Waller, 2007). For good development of embryo, it is essential that nutrients are deposited in the eggs. And this is when the nutrition of the breeder stock becomes a matter of importance (Qiao, 2008). According to Kenny and Kemp (2005) chicks hatched and the embryo formed all depend on nutrients embedded in the eggs for their survival i.e., their growth and development. The physiological state of the chick during hatching is primarily due to how the breeder flocks was fed which will then have an influence on size of chick, strength and how well its immune system is built. For success in broiler production, a chick must have right body weight with excellent nutrition reserves at day old, especially; essential amino acids are needed for cell membrane building, immune strength and embryonic development which affect chick quality (Qiao, 2008).

Breeder nutrition according to Waller (2007), is that right amount of nutrient given to the breeder which is made up of two parts, nutrient composition of the diet and amount of feed given to breeder birds. Both composition need to be in the right proportion to ensure correct daily nutrient allocation. When feed is not given in the right amount and quality it has a negative influence on the later stages of embryonic development when parent stock have in early production period. Presently, the hybrid parent flock start producing at a faster rate than it used to be hence, egg production tend to increase over a shorter period of time particularly in the early laying period. Feed allocations during this period have not being at par with the increase in the egg production pattern. Feed allocated to young commercial breeder flocks is very low and has been observed to interfere with the nutrient transferred to the egg ending in increase in late embryonic death, less quality chick growth and bird uniformity even though this is unintentional (Waller, 2007). In a study by Leeson (2004) broilers were given feed of varying levels during their peak levels from 140 to 175 grams. Even though the increased feed given saw an increase in body weight there was no change in egg size, but the chick weight was affected by feed given to the birds.

Research according to Kenny and Kemp (2005) shows that nutrient given to the broiler breeder affects the quality of chick and the production performance. This puts more importance on the right amount of nutrient density diet and the right feed intake by the bird which is about to start laying. Figures indicates that peak feed supplied to breeders are 140,147,155,162,169,175(g/b/d) which corresponds to 40.3,40, 41.5, 41.7, 41.8, 42 (g) of breeder weight at 30 weeks (Kenny and Kemp, 2005).

It is known that there is better breeder performance when maize is compared to wheat as the main grain in breeder feeds (Kenny and Kemp, 2005). From a survey of many depleted commercial farms, overall hatch of fertile eggs in the UK based on wheat diets and Brazil based on maize diets were 83.3 and 86.2 per 100 eggs respectively (Kenny and Kemp, 2005). People use maize because of its effect on shell quality and its thickness (Kenny and Kemp, 2005). Calcium, phosphorus, sodium, potassium, magnesium and chloride are part in the shell formation therefore when the quality of shell is good it will yield better egg and better chick characteristics (Kenny and Kemp, 2005). Most interest has been heightened in the chelated minerals deposits in the egg which is usually used in the feed given to the birds and subsequently transferred into the tissues of the bird and the embryo too. When fat is added it should be minimal (1-3%) concentrating on unsaturated vegetable oils instead of the saturated animal fats. Maize oil added increases body weight within 21 days over poultry fat and improved broiler weight at slaughter in comparison with equal levels of poultry fat and lard (Kenny and Kemp, 2005).

Low crude protein in breeder feed changes the body composition at the time of rearing. This affects in a good way the hatchability of the birds during the first phase and egg production during the second time of the laying period. According to Poultry scientist Van Emous (2014) there is an effect of high and low dietary protein levels during raising of bird and the amount of feed taken on body formation by the end of the raising and reproductive performance of the females. A sum of

2880 day –old Ross 308 broiler breeder chicks were kept in 36 pens and for 60 wks were monitored. In meeting the body weight at age 22 wk, the average feed intake plummeted by 12.8% for the young birds which were fed on low protein diet. At 22wks females fed the low protein diet had 15% less breast muscle however had abdominal fat increase by 86%, compared to fed on a high protein diet. This caused an increase in hatchability by 1.3% because of a decrease in mortality in embryo in the first phase of the time of laying (23-45 wk of age). The birds fed on low protein diets produced 3.6 more of eggs in the second phase of time of laying (46-60 wk of age) (Van Emous, 2014).

Water is an important nutrient (Klasing, 2015). Several factors affect water intake including temperature of the environment, relative humidity, presence of salt and protein in the feed, birds' performance (growth and egg laying) and the birds ability to reabsorb water in the kidney. Water deprivation for ≥12 hr has a serious repercussion on growth of young broilers and egg production of layers and water deprivation for ≥36 hr increased mortality greatly. Uncontaminated, cool, clean, odourless water, devoid of high levels of minerals or other potential toxic substances, must be supplied *ad libitum* (Klasing, 2015).

2.3 Hatchery

Hatchery as a segment of the poultry production chain mainly to produce day old chicks safe to start the poultry production chain. It is said that the productivity of a hatchery is the total number of first-quality chicks produced. This is called saleable chicks. This number of salable chicks expressed as a percentage of all eggs set to be incubated is normally referred to as hatchability

(Cobb Hatchery Management Guide, 2008). Hatchability depends on many factors. Some of these factors depend on the condition prevailing at the breeding farm and others are placed at the door-step of the hatchery. Those controlling factors on the farm include breeder nutrition, diseases, infertility, egg damage, egg sanitation and egg storage. In the hatchery the factors include sanitation, egg storage, egg damage, incubation (management of setters and hatchers) and chick handling. Thus the breeder farm has a major part to play in the results that come out of the hatchery and it is paramount for both stations to work together to achieve a positive result

(Cobb Hatchery Management Guide, 2008). Hatcheries act as a 'funnel', taking hatching eggs from very few breeder farms and producing day-old chicks to a much larger number of broiler and layer produces. Even though this does increase the risk of disease transfer this can be toned down by excellent hygiene practice (International Hatchery Practice, 2015). The activities of the hatchery are affected by numerous factors including incubation temperature, relative humidity and eggs handling.

Incubation temperature and the optimum temperature ranges between 37.5-37.7°C at the development stage and 36-37°C during hatching period which is considered as a core determinant in the incubation process (Decuypere *et al.*, 2001; Meijerhof, 2009). The egg shell temperature seeks to determine the embryo temperature and in turn is impacted by breeder age, embryonic development stage, heat generated by embryo, heat transfer between egg and environment, air temperature in setter and hatcher, air velocity and relative humidity (Hamidu *et al*., 2007;Lourens *et al.*, 2007). In commercial hatcheries, by the second stage of incubation (day 9 of incubation) optimal temperature is not easily reached due to excessive heating produced by the embryo growing (Lourens *et al.*, 2007). It suppresses heart, intestine development and also yolk sac absorption. Embryos growing at a much faster rate are very sensitive to temperature changes.

Consistent changes that occur within the optimal temperatures could impact negatively on the development of the embryo and possibly affect hatchability and day-old chick quality (Molenaar *et al.*, 2010). Wineland *et al.* (2000a, 2000b) emphasized that the heart at hatch is one of the fore-most organs affected in the hatchling when temperatures are suboptimal which can during hatch period. It results in putting pressure on the heart-tissue system during embryonic development. As a result of this, a metabolic disorder called ascites occurs. This is caused by abnormal changes in incubation temperatures, which occurs during 5th and 6th weeks of rearing and causes economic losses to the farmer (Coleman and Coleman, 1991).

The relative humidity is another factor which has serious effect on the hatchling quality and incubation effect. Bruzual *et al*. (2000) reported that optimum relative humidity should range between 50-60% for optimum incubation results. During the incubation, there is an acceptable level of egg weight loss which should be within the range of 12-14% by transfer at 18days (Molenaar *et al.*,2010).When egg weight loss is between 6.5-13.5% until the time the neonate pips, it is not enough to get the right air cell size to begin lung respiration (Molenaar *et al.*,2010). At incubation, a lower humidity levels causes the hatchling to be small, dehydrated and sticky (Deeming, 2000). Navels that are uncovered become a problem during higher relative humidity level. It inhibits utilization of yolk sac, induces yolk sac infections, and increases first week chick mortalities. The higher humidity seems to favour better growth and feed conversion (Winn and Godfrey, 1966). For male broilers Yahav (2000), stipulated that the effect of relative humidity (RH, 41% to 75%) at moderate ambient temperatures during incubation (ranging 28^{O}C to 30 ^{O}C) in relation to the performance test and thermoregulation of the male broiler chickens and turkeys at ages 4-8 week showed that weight gain and the feed ingested by the male broiler chickens were significantly higher ranging from 60%-65% of relative humidity. Feed conversion efficiency was however not affected by relative humidity. The rate of panting by the animals from the blood's pH and pCO_2 are lower in chickens exposed to 28 ^{0} C than to 30 ^{0}C (Yahav, 2000).

The condition of the egg is directly related to how well the flock is taking care off. Feeding a well-balanced ration, supplemented by calcium with oyster shell, enough water supplied, flock age and health all can affect egg quality (Clauer, 2009). The care of hatching eggs during storage at the farm, during transport or at the hatchery - is an important aspect of hatchery management that aims to preserve the strength of the embryo (Pas Reforms, 2015a).

It is important to check out for normal size, shape, colour and shell texture. Extremely large or small eggs are often less productive and hence must not be set (Lyons, 2015). Eggs with general defects must be removed; dirty eggs and cracked ones should be removed. Set hatching eggs with its large ends up, and then store at a cool dry place (Lyons, 2015). For best hatching results, do not store fertile eggs for 14 days or more. Eggs hatch well when set between three to four days after laying. It should be noted that old eggs stored long well could hatched without complications (Lyons, 2015). 'Sweat' occurs when eggs at lower temperature are exposed to a sudden to high environmental temperature or relative humidity (Pas Reforms, 2015). Moisture on egg shell surface promotes the growth of microorganism and this must be prevented. This microorganism then clogs the eggshell pores when the egg cools off and its contents contracts which causes a decrease in internal pressure (Lyons, 2015). Eggs with loose or movable air cells should not be set, because of reduced hatchability (Lyons, 2015). Whenever eggs are soiled, clean by sanding the area soiled but it could be detrimental to the egg because it removes the cuticle on the egg shell surface. The cuticle is a biological coat on the eggshell which is dry and waxy when the egg was laid (Lyons, 2015).Washing the eggs also removes the protective cuticle exposing the egg to get contaminated. The best practice is not to incubate dirty egg which should be removed.

2.3.1 Hatchery Hygiene or Biosecurity

Hatchery hygiene (International Hatchery Practice, 2015) is an important fundamental factor in incubation, just as temperature, relative humidity, ventilation, and turning the eggs. From the World Poultry Site (2006) the hygiene in the hatchery is the first place to determine condition of breeder flock. Hatcheries are almost always being exposed to pathogenic organisms such as bacteria, mycoplasma and fungi from eggs coming from several sources. Several factors such as hatching eggs received from a single infected breeder house, persons, transport equipment, rodents etc. can act as a vector for these microorganisms. (International Hatchery Practice, 2015) .Optimized hygiene in the hatchery is dependent on three key areas:

- Preventing pathogens from entering the hatchery i.e. maintaining biosecurity
- Avoiding cross-contamination or the transfer of pathogens within the hatchery
- Inhibiting further pathogenic development in the hatchery i.e. cleaning and disinfecting There should work together with optimism biosecurity (including thorough farm cleanliness and disinfection programme) and also care regarding all the vectors that may affect eggs before they even reach the hatchery. The delicate hatching eggs are at risk from:

(a) external contamination through the parts of the shell

(b) vertical transmission (from infected flocks)

(c) internal contamination (yolk and albumen)

(d) vectors such as hands, trays, transport equipment etc.

The world Poultry Site (2006) shows that it is important that biosecurity be developed for trays, pedigree boxes, egg collection tables and hands that touch the eggs. The equipment can be sprayed with a full spectrum disinfectant which is not corrosive with residual action. Hatchery workers hands must be cleaned first and foremost with soap and disinfected with an alcohol based liquid or gelly product. Ideally, eggs should be disinfected when collected immediately at the farm and again at the hatchery. In multistage setters, there is growth of bacteria constantly, to curb this is to ensure regular disinfection and exploded eggs should be removed and their debris cleared up. Formaldehyde cannot be used to spray the setter since it has carcinogenic properties and residues of it will encourage recontamination of bacteria (World Poultry site, 2006).

2.4 The Egg

The egg of a laying hen goes through a lot of processes before it is laid. It is the vehicle for birthing chicks and serves as a source of protein to be consumed by humans (Jacob *et al.*, 2000). The poultry egg acts as a microhabitat which houses embryo that develops to live in the next generation in the physical world (Amankwah, 2013). The content and composition of the egg influence the growth of the embryo contained within the egg including the hatchling and the future performance of the flock (Amankwah, 2013).. As a complex reproductive cell, it is the seat of life developing. It all starts with the development of the blastoderm of the embryo. The albumen which surrounds the yolk protects this hub of life that is forming. It is an elastic, shock –absorbing semi-solid structure with high water content. The yolk and albumen together sustains life of the growing embryo to three weeks in chickens. The albumen is surrounded by membranes and an external covering called shell which helps for gaseous exchange and mechanically conserving food and supplying water to the embryonic organism (Jacob *et al.,* 2000).

The left oviduct is the first and foremost place where the yolk is ovulated to start the formation of the egg. The ovulated yolk resides in the infundibulum where the egg in process stays for about fifteen minutes for the perivitelline membrane and chalazae to be forms. In breeder birds in general, the oviduct is the place for fertilization (Solomon, 1991). The egg will then enter the magnum and stays for three hours for the albumen to be added (protein) to be formed. The proteinous layer form protection for the yolk against mechanical and bacterial infection and thereby setting a layer for shell membrane and shell formation. The developing egg then enters the isthmus where a fibrous layer of the inner and outer shell membranes are added (Johnson, 2000). The forming egg enters the shell gland so that water and electrolytes could penetrate the albumen to form the mammillary cores which in turn forms the eggshell. The structure formed on the eggshell is made up of the following organs, shell membranes, the mammillary cores, the shell matrix and the cuticle. The portion known as the inorganic part of the eggshell is made up of calcium carbonate (Nys *et al.*, 1999; Lavelin *et al.*, 2000). Finally, the egg is laid through the vagina and cloaca. The complexity of the formation process of the internal composition of an egg reveals that problems associated with quality could emerge from any part of the formation stages of the egg (Jacob *et al.*, 2000).

2.4.1 The Egg Quality and Hatchability

The chicken egg is a biological capsule made for birthing new individuals and it acts as a complete food for the developing embryo (Jacob *et al.*, 2000) and nutrients for man. Quality by Kramer (1951) is that property of a particular food that has the ability to be accepted or rejected by its customer. Egg quality according to Islam *et al.* (2001) is its ability to reproduce a strong offspring by the parents. External quality (eggshell) consist of the following: the egg weight, width, length and shell characteristics (Olawumi and Ogunlade, 2008) and those of the interior of the egg. The microbial condition of the inside of the egg will determine the condition of the eggshell to regulate micro-organisms entering into the egg. Measures that relate to the positive attributes of the interior conditions of the egg are termed as the internal quality trait of the egg and it relates to the functional, aesthetic and microbiological contamination of the yolk and albumen (Sabri *et al.*, 1999). Both external and internal qualities of eggs in hens have significant effect on hatchability of incubated and fertile eggs as well as the weight and development of chicks (Amankwah, 2013). Exterior quality includes its weight, shape, colour, shell thickness, shell weight, shell density, texture, egg surface area, and cleanliness of the egg (USDA, 2000; Hussain, 2011). The egg should have its size, shape and colour to be the same; its shell should be smooth, neat and has no cracks. Egg weight, shape and shape combine to form the external feature which in turn affect the grading characteristic, pricing and customers' likeability and hatchability (King'ori, 2011; 2012). Shells can have five main problems in the egg industry: cracks due to excess pressure, cracks due to thin shells, body-checks, pimpled or toe holes, and shell-less eggs (Kontecka *et al.*, 2009).

Internal quality refers to all the inside of the egg including the egg yolk, egg white (albumen) how clean it is, size of the air cell, yolk shape and yolk strength and assumes functional, aesthetic and microbiological properties of the yolk and albumen. According to Encyclopedia Britannica (2012) a fresh egg is composed of yolk -32%, albumen-58% and 10% shell.

Albumen of the egg is the clear liquid surrounding the yolk; its primary role is to protect the yolk. It provides supplementary nutrition for the growth of the embryo. The egg white also known as the albumen is formed by four main structures according to Kontecka *et al.* (2009). Firstly, the chalaziferous layer or chalazae, surrounds the yolk first, making up about 3% of the egg white. Then followed by the inner thin layer, which surrounds the chalazae and makes up for 17% of the white. Third layer is firm or thick layer, which serves as a barrier to the thin white and the yolk. It cleaves to the shell membrane at the ends of the egg and makes up for 57% of the albumen. The outer and final, thin layer which is 23% of the egg white covers inside the shell membrane with the exception of the part of the shell where the third thick layer is attached to (USDA, 2000). It is highly rich in protein, has less fat compared to the yolk which has a higher fat which is usually associated with high cholesterol content. The yolk is the yellow spherical part of the egg engulfed by the albumen.

Also both the internal and external traits of the egg are important when it comes to crossing the birds especially during influence on yield in the next generation, their breeding performance and trait of eggs which affect prices of the eggs .The weight of the eggshell, albumen and yolk and their compositions affect the amount and price of the egg (Altan *et al.*, 1998). Egg weight is an important performance trait which is responsible for egg quality and grading (Farooq *et al.*, 2001a). This is one parameter which could determine everything about the egg without break open the egg (Wilson and Suarez, 1993; Farooq *et al.*, 2001b).The composition of the eggs varies among species. The size of the egg varies within population and to a lesser extent within clutch of birds. Egg size is a main factor which determines size of the chick. Poultry body weight is known to be moderately to highly heritable; therefore, selecting heavier broiler birds could improve on the size of the egg (Ayorinde and Oke, 1995). The weight of an egg has a direct relation to the weight of the albumen, yolk and shell it contains and this varies significantly with strains of the parent flock (Amankwah, 2013). Amankwah (2013) reported that bigger hens lay bigger eggs than those with smaller body weight. Egg length, is measured as the height of the egg and the longest part of the surface of the egg. It is also the longest border while the width is the shortest portion of the egg and it is also the breadth and that is where the dense mass of the yolk is situated (Gunlu *et al.*, 2003).The physical characteristic is paramount to the processes of the embryo development and subsequent hatching. The most influential egg parameters are the egg weight, shell thickness, shell porosity and shape index. Embryo development is wrapped up in the average value derived from egg quality traits. Shell thickness and firm interiors result in successful embryo hatching which is as a result of higher egg weight (Narushin and Romanov, 2002). It is known that external and internal egg quality traits have an effect on the subsequent generations they produce and their performance (Islam *et al.*, 2001). In several species large egg size results in increased size of chick, rate of growth and survival. This is because the composition and content of the egg have an effect on the successive development of the embryo and may affect the survivability of the newly hatched chicks. Thus, as the embryo grows at a constant rate during incubation along the egg content (Wilson, 1991)**.** Researches have indicated that with increasing egg mass there is an increase in hatchability although egg size does not affect the survivability. Several researches have made assertion that egg components relatively have the ability to determine the quality of the egg. Again dry component of the albumen is crucial factor in determining egg quality (Wilson, 1991)**.** Egg albumen surrounding the egg yolk, which contains more proteins, increases in mass better than the whole of the egg providing protein for the tissues of the embryo for its growth (Fayeye *et al.*, 2008). During embryo development chicks from larger eggs do not have any competition with other chicks since they have enough nutrition to support them (Reijrink *et al.*, 2008). The yolk sac provides nutrients to the growing embryo towards the end of the incubation and also sustains it during the first few days after hatching (Reijrink *et al.*, 2008).). Moyle *et al.* (2008b) added that egg shell quality is known to have a positive effect on hatchability. The main factors that influences egg shell quality includes genetics, diet, climate, housing and age of the parent stock. Again, Moyle *et al.* (2008b) asserts that eggs with a slimmer shell are more likely to crack or break and these do not pass for setting in the incubation. They break in the nest boxes during collection and transporting, ending up as poor hatchlings due to contamination. Again shell breakage, or body checked eggs easily evaporates water during the incubation process resulting in dehydration and eventual death of the embryo (Moyle *et al.*, 2008a).Those chicks that survive from cracked eggs, have a short life span and poor performance some research indicating that there is some relationship between colour of eggs hatched and ability to be hatch. Eggshell color may also be associated with egg shell quality. Poultry producers according to Moyle *et al. (*2008b) believe that breeds that lay brown eggs do not hatch early just like the ligher coloured eggs. However, Moreno *et al.*, (2006) stipulates that certain songbird species (flycatchers) which have healthier more well fed females lay more intensely coloured eggs. Thus, there is. According to Beyer (2005) there are several factors which come together to affect the egg quality. Some of these factors can be manipulated to play key role in its quality by ensuring better management and genetics, feed quality and environment. The most reliable factor is the age of the breeder. A young bird (pullet) produces smaller eggs, thick egg shell and good quality albumen. As the hen grows older the shells becomes thin, albumen weaken and looses its elasticity. Birds can be molted to another egg cycle to improve egg quality if not they will have to be replaced with a new set of young pullets (Beyer, 2005).

According to Donohue (2009) hatchability is the amount of chicks hatched expressed as a percentage from every 100 hatching eggs set in incubators. Eggs sent to the hatchery means that a set of day old chicks are needed to be produced (Cobb Hatchery Management Guide, 2015). Hatchery managers generate an optimum conditions for embryos to thrive in order to produce the greatest number of high profile quality day old chicks and eventually attain the best broilers (Cobb Hatchery Management Guide, 2015). This number is in percentage of all the eggs set for incubation. Hatchability is affected by both the activities within the breeder farm and the hatchery.

Irrespective of the machine used for incubation at the hatchery, these devices generally regulates temperature, humidity, ventilation and turning of the eggs in an optimal incubation environment (Meijerhof, 2009). Temperature affects the metabolic rate of the embryo and its development. It is more likely that an embryo could produce more heat to the detriment of the itself due to the excessive heat being produced by recent breeds of broilers (Meijerhof, 2009). At the time of incubation, water is lost by evaporation from eggs. In reality, egg losses about 12% of its weight before day 18 of incubation (Taylor, 2000). Air for ventilation according to Taylor (2000) leaves the setter, gets rid of carbon dioxide and the extra heat generated by the developing eggs. Eggs are turned consistently during the time of incubation to prevent embryos from sticking into the membranes of the shell in the first week of incubation and help in development of the embryo (Cobb Hatchery Management Guide, 2015). As embryo grows, the heat increases alongside. Consistent turning is needed to help airflow and increase cooling. Optimum temperature, humidity, ventilation are essential for optimum hatchability (Sozcu and Ipek, 2013).

2.5 Chick Quality

Chick quality is a term that many breeders use however; farmers still have difficulty in defining it although quality of day-old chicks is on the minds of poultry managers (Decuypere *et al.,* 2007). Most poultry farmers can identify chicks in good standing (quality) but when asked to mention what makes chicks a better quality a different interpretation will be given (Fairchild, 2005). According to Willemsen *et al.* (2008) chick quality has traditionally been a combination of hatchability and a three day mortality assessment post-hatch. It includes a wide range of characteristics at assessment time that evaluate prior practices or could relate to potential for health or performance in the post hatch period (Elmehdawi, 2013). A hatchling of good quality should look neat, dry, devoid of dirt and contamination, with clear and bright eyes, no deformities and with a completely sealed and clean navel (Decuypere *et al.,* 2007). The chick must have no yolk sac or dried membrane seen attached from the navel area. Its body should not be wet when touched and have no breathing difficulty. The chick should not be hyperactive but sober and responds to sights and sounds within it immediate environment. Its legs should be normal and no deformities (Raghavan, 1999). Decuypere *et al.* (2007) stated that as a crucial step in the production of day-old chicks of high quality, there are some factors that will be needed to take into consideration; that is the genetic makeup of the stock (Peebles *et al.,* 2001), the feed and water requirements of the breeding birds during growth and production, the age of the flock, their health and the management of the male birds (Decuypere *et al.,* 2007). According to Decuypere *et al.* (2007), hatching success and the quality of the chicks produced has traditionally been the yardsticks by which a hatchery or the incubators in it are judged. Quality of hatching eggs improves the level of hatchability and promote good chick quality (Yoho *et al.,* 2008, Moyle *et al.*, 2008). There is a link between hatching success and chick quality according to Decuypere *et al.* (2007), leading to the idea that, if hatchability has been maximized, chick quality is also automatically optimal. Again chick quality is affected by several factors which may not be limited to pre-incubation factors such as physical condition of the parent stock, level of development of the parent at ovi-position, time taken and the conditions prevailing between ovi-position and storage and the storage conditions at the hatchery (Barri, 2008). The external factors which also affect conditions of the chick during incubation include incubation temperature, humidity, ventilation, air speed and egg turning (Barri, 2008). These factors affect the physiology of the developing embryo (Barri, 2008). Incubation conditions increase in importance as selection of different traits in broiler continues, given that the environment of the embryo would improve to affect stages of development and have an impact on the chick quality and the post–hatch chick (Barri, 2008).

2.5.1 Factors Affecting Chick Quality

2.5.1.1 Incubation Temperature

Incubation temperature is possibly the first factor that has a toll on chick quality (Lourens *et al.*, 2006). This is because investigation conducted by several researchers showed that its manipulation during embryogenesis has long lasting effects on growth and performance (French, 2009; Hulet and Meijorhof, 2001). Normal incubation temperature ranges from (37-38 ^{0} C) and can properly control chicken embryonic development. Temperatures outside this range can accelerate or decrease embryogenesis and hatching thus, placing temperature as one of the most important environmental factors (French, 2002). Chicks that hatched from low incubation temperature during early embryogenesis had different body weight due to differences in yolk sac weight but chicks that hatched from high temperature during late embryogenesis had differences due to weight of yolk-free body weight (Joseph *et al.*, 2006). It has been established that chicken embryo has to lose 12% to 14% of their fresh egg weight before pipping to have a good chance of a successful hatch (French, 2009). Embryos during incubation produce heat during metabolism of the yolk, therefore the temperature regulation must be carefully considered since too much may lead to increased metabolism which would also lead to increased heat production and lack of oxygen to the embryo (Lourens *et al.,* 2007). Deeming (2000a) added that heat could lead to poor growth rate, inability to fully utilize albumen protein and stress of embryo and eventually high mortality and poor chick quality at hatch. The goal of hatcheries therefore should be to obtain as many saleable (marketable) chicks as possible. It is well known that good hatchability is positively correlated with post–hatch viability and performance of chicks (Tona *et al.,*2005). Higher or too low temperatures during incubation through several researches have an effect after hatch growth (Lekrisompong, 2005) and proper organ development of avian embryos (Shafey, 2004). Research has shown that the optimum temperature for incubation needs to be around 37.0^0C (98.6^0F) to 38.0^0C (100.4^0F) for chicken eggs (Lekrisompong, 2005) and 37.5^0C (99.5^0F) for turkey eggs.

At low temperatures heat for optimal metabolism is not enough so chicks take longer time to dry resulting in longer hatching time (Deeming, 2000a). Deeming (2000a) also added that at hatch there is high mortality rate and large staggering chicks due to low incubation temperature. The chicks also become small in size since nutrients resources are used properly for survival in the first week of post hatch for growth and development (Cazaban, 2005).There have been many experiments carried out by researchers on the effects of manipulation of temperature during embryogenesis and its effects on chick quality (Elmehdawi, 2013) also in the changes that happen in the colouration as in plate 1 below. With increase of incubation temperature during late embryo development there was elevated plasma blood weight concentration and strain by the treatment alteration in insulin-like growth factor concentrations (Willemsen *et al.,* 2011). The quality of hatched chick is also affected by the changes that occur in the hormones associated with metabolic reaction in the body and the growing out of the embryos which could be linked to temperature variation (Decuypere and Bruggerman, 2006).

Plate 1: Distinguishing chicks incubated at higher (38.9^0C) and high (37.8^0C) temperatures. Yellow chick incubated at high temperature and white chick incubated at higher temperature. Source: Leksrisompong (2005)

2.5.1.2 Relative Humidity

Relative humidity is an important factor affecting chick quality. Measuring and controlling relative humidity requires much effort, therefore making it commonly misunderstood since it has a relation with temperature and ventilation (Deeming, 2000a). Hatching success in broiler eggs is as a result of the dehydration from the egg during the time of incubating the eggs (Buhr, 1995).

The porous nature of eggs, allows water into and out of them making the humidity of the incubator a determinant of this action (Perez, 2007). All eggs contain airspaces and as the eggs begin to dry out the water is being replaced by more airspaces. Therefore the more water that is lost the size of the airspaces increase. The airspaces is very important in incubation since the chick uses it to breathe and also give it space to maneuver into hatching position (Deeming, 2000a). With high humidity little airspaces is made available for the chicks. This affects their respiration and makes it difficult for them to break out (Deeming, 2000a). High humidity also results in large, weak and often sticky chicks with unhealed navels. Low humidity leads to larger airspace, small dehydrated and sticky chicks at hatch (Deeming, 2000a).

2.5.1.3 Ventilation

Poor ventilation leads to the fluids collecting around the embryo which is caused by low levels of oxygen and high levels of carbon dioxide (Deeming, 2000b). Carbon dioxide is needed in very small quantities (0.1-0.4%) while higher concentration (0.5-0.8%) reduces livability of chicks (Decuypere *et al.,* 2001). Although high carbon dioxide concentration serves as a stimulant to early embryonic development, it may also slightly increase the pH during these early embryonic stages (Decuypere *et al.,* 2001). During the last period of embryonic development, increase in carbon dioxide concentrates can also stimulate hatching process (Willemsen *et al*., 2008).

2.5.1.4 Turning

The turning of eggs is important for the positioning of the embryo in the eggs and also see to the forming of the membranes formed by the embryos (Deeming, 1989). When turning is not done, the embryo adheres to the inner parts of the shell membranes, embryonic malposition, retarded growth of vasculasa, inability of the albumen and yolk to be utilised, a lack of sub-embryonic fluid and inability of the oxygen to be absorbed and released (Sozcu and Ipek, 2013). In addition to these, absence of turning results in lower hatchability and those chicks often hatch late and clammy (Deeming, 2000b). Turning also helps in distributing heat throughout the embryo thus increasing hatchability (Elibol *et al.,* 2002).Turning is also important during the initial stages of incubation (Elibol *et al.*, 2002). Tona *et al*. (2003) indicated that turning during the first week when incubation starts helps in the formation of extra–embryonic membranes but in the first week avoid the abnormal positioning of the embryo. In another study, Elibol and Brake (2004) assessed the lack of turning resulting in presentation of the head in the small end of the egg. Egg turning promotes the absorption of nutrients in the yolk to the embryo through the subembryonic fluid. The work of Elibol *et al*. (2002) have provided evidence that turning reduces all stages of embryonic mortality while poor or no turning increases mortality, late hatching and chicks that have not been dried off normally (Deeming, 2000).

2.5.1.5 Storage Duration

Prior to incubation, the duration of egg storage affects chick quality (Tona *et al.,* 2003). Storage before incubation may have both the pros-and-cons implications on chick quality which is dependent on storage time (Reijrink *et al.*,2009). A lot of investigation has been conducted on the effect of pre-storage incubation to reduce the negative effect of egg storage on hatchability (Fasenko *et al.,* 200l a, b). It was generally concluded that pre-storage time from day zero to day6 had no effect on hatchability, however, when the time was increased beyond that it could be both beneficial or detrimental (Reijrink *et al*., 2008). An experiment was conducted by Reijrink *et al*. (2008) to determine the influences of pre-storage on chick quality. Two experiments were involved. In the first experiment eggs were stored for 3,5, 8 or12 days. In the second experiment eggs were stored for 5 and 11 days. Half of the stored eggs were placed under temperatures ranging from 16 to 18^0C while the other half were pre-stored for 6 hours in the first experiment and 4.5 in the second experiment. In the first experiment, pre-storage incubation reduced hatchability when storage time was 3, 5 or 8 days. Storage before incubation saw chick length go up. In experiment II, pre-storage incubation increased hatchability of fertile eggs (went up from 80.6 to 85.9%) when storage time was 11days but there was no increase in hatchability when storage time was 5days. Pre –storage incubation soared in the percentage of the second grade chicks. It could be noted that longer storage time, ensures that embryonic development at egg collection and pre-storage time has no known effect on hatchability and quality of the hatchling. In another research .it has been found that eggs stored for longer duration (18-days) resulted in delayed hatching and the delay in hatching was attributed to delay in the initiation of embryogenesis (Fasenko, 2008). There were also greater occurrence of severe abnormalities from eggs stored beyond 7-days (Tona *et al.*, 2003) than those stored for lesser duration (3-days).

This shows also in the effect of the egg's internal quality, especially albumen height during storage (Tona *et al.*, 2002).

2.5.1.6 Pre-Warming

Pre-warming eggs before hatching before incubation prevents condensation and also reduces changes that occur within the environment of the egg temperature. This process affects embryo viability, as it affects cell death especially when cell viability is reduced after prolonged storage (Reijrink *et al.*, 2008). In nature, each hen heats their eggs through direct contact with her brood patch and turns the eggs frequently at the beginning of incubation. Therefore, the two major things that a hen has control over are turning frequency and egg temperature. Elibol (2006) that hens keep turning or shift their laid eggs in the natural environment about 96 times in the day . In his review, Wilson (1991) reported turning eggs 96 times daily to be the optimum rate. However, due to maintenance costs associated with the machines and relatively small differences in hatchability, most companies turn the eggs 24 times daily (Elibol, 2006). Temperature on the other hand, has also been considered to be one of the most influential factors on embryonic growth and development during all stages of incubation. Fasenko *et al.,*(2001a) demonstrated that the hatchability of long stored eggs exhibited a greater percentage improvement when preheated prior to standard incubation than those eggs that were stored for only a short time. Hodgetts (1999) suggested that eggs could be in a state of shock if warming is not done slowly while Wilson (1991) suggested that it was favorable to mildly heat eggs rapidly to incubation temperature. Yuan *et al.,(*2009) indicated that the chicken egg at the time of lay was in the process of active hypoblast formation. Due to the fact that eggs have been found to be in different developmental stages at the time of oviposition, preheating has become a part of hatchery management as preheating has provided a means to incrementally increase the temperature of eggs just prior to incubation. This has been found to be beneficial for eggs that need to be transformed into a state more ready for incubation. Increasing egg temperature to an intermediate range, the eggs were made to achieve temperature more easily when set. This has been suggested to promote early embryonic growth (Güçbilmez *et al.,* 2009). Embryos from broilers strains meant for commercial purposes worldwide are usually intolerant of temperature variations with abnormality and death of the embryo being the extreme of case of exceeding the range of the temperature has been thought to be optimum for incubation (Wilson, 1991). Brannan (2008) mentioned that preheating allowed embryos to more safe and adequately adjust to the dramatic increase in temperature between an egg cooler and an incubator. Eggs being preheated experienced high air velocities were warmed rapidly, while eggs at a low air velocity took several hours to warm (Elibol and Brake, 2008). Wilson (1991) and Lourens *et al.* (2005) suggested that it was favorable to mildly heat eggs rapidly to incubation temperature.

2.5.1.7 Short Periods of Incubation During Egg Storage ("SPIDES")

It is common practice for hatching eggs to be stored for several days before starting incubation. If temperature (18-20°C) and humidity (75%) in storage rooms are controlled properly, eggs can be stored for more than seven days with adverse drop in hatchability. Longer periods of storage however do affect the viability of the embryo (Pas Reforms, 2015). Earlier, Decuypere (1992) showed that hatchability increased when eggs were incubated for short periods before being stored. At the turn of the century, Fasenko (Fasenko *et al.*, 2001a; Fasenko, 2007) reported that after six hours of storage before incubation, chicken embryos reach the more storage resistant hypoblast stage of embryonic development. Even though Dymond *et al.* (2013) suggested alternatively that eggs introduced to short periods(less than 6 hours) of incubation at consistent intervals during a longer time of storage would allow the embryo to repair its cells and also minimize death. In the broiler industry, embryonic temperature stimulation during pre-storage incubation has been adapted still further to deliver multiple periods of stimulation. Dymond *et al.*

(2013) have shown that three-to-four 'Short Periods of Incubation During Egg Storage' – or 'SPIDES' - of 21 days increased hatchability and reduced hatching time. This depicts the natural settings where hens sit on the eggs to bring to lay, rewarms the eggs laid initially and then keeps coming back to sit to lay more eggs(World Poultry, 2014). According to data from Pas Reform (2015) when practicing SPIDES, eggs are transferred from the storage room to a pre-warmed or running incubator and cooled again to storage temperature as soon as eggshell temperature reaches a maximum of 32°C. The time needed to reach 32°C (90°F) varies with incubator type, but is typically after 3-6 hours incubation at 37.8-38 °C (100.0-100.4 °F). To prevent embryos from developing beyond the storage resistant stage, care must be taken that, during the complete or multiple SPIDES treatments, the cumulative time that eggshell temperature rises above 32°C (90°F) does not exceed 12 hours. One treatment of pre-storage incubation or multiple treatments (SPIDES) tends to improve hatchability and internal chick condition if eggs are stored for seven days or more. During SPIDES the interval between incubation treatments is typically 5-6 days (Pas Reforms, 2015). SPIDES increase hatchability by about 2-3% especially for eggs stored for about one to two weeks. SPIDES is not a short cut to recovery from poor hatchability but it minimizes the rate of decrease of hatchability caused by the long period of egg stored (Aviagen, 2014).

2.6 Assessing Chick Quality

Chick quality assessment is usually based on data obtained from hatcheries and grower houses. In generalized term chick quality must relate to the general health of the bird to give higher meat yield or increased egg production at the end of its term. Geidam (2003) quoting Cervantes (1993) stipulated that a fixed number is needed to define standard chick quality. Here chick quality has been defined by arriving at a numerical value for grading chicks first to broiler then later to pullets.(Koteeswaran *et al.,* 2004). This numerical value is as a result of three parameters that is physical, microbiological and serological specifications (Koteeswaran *et al.,* 2004).

2.6.1 Visual Score

This method is a scoring by observations. Even though it is subjective it is rather precise. Most people tend to use the same principles more or less. The first thing to consider is the colour of the day old chick, most people prefer bright yellow day old chick. And even though not intensively investigated, it is assumed to have a connection with embryonic development. The yellow pigment emerges from the yolk and since the yolk is the energy needed for embryonic development, more yolk uptake would mean more yellow colour and likewise a well-developed hatchling (Geidam, 2003). At times the yellow colour is induced by formaldehyde in the hatchers however this does not lead to better developed chick (Meijerhof, 2005). The excessive use on formaldehyde during fumigation is therefore often criticized besides its harmful effects on human health. Second parameter is the general development on the chick that includes the development on the feathers, firmness of the keys, size of the beak and eyes among other things. The third is navel score a poorly closed navel; or yolk sac infection can lead to mortality. The last parameter is the vitality and alertness of the chick which is largely as a result of hatchery condition (Geidam, 2003). The visual score of a knowledgeable hatchery manager might estimate good chick quality but the system still remains subjective and poorly reproducible (Meijerhof, 2005).

2.6.2 Tona or Pasgar Score.

Moves that were made to make the visual score trial worthy, led to the development of the Tona score, simplified to a more practical method by Pas Reform called Pasgar score. These methods put the visual scoring of a hatchery worker on a significant importance and to a certain degree reproducible scale (Geidam, 2003). With this method, a series of observation are scored from 110 and trained personals are brought in to determine the condition of the day old chick in a more precise and reproducible form (Geidam, 2003). Measurements of primary importance are the viability of the chick, absorbed yolk sac, navel closure and the ability of the chick to get back on its feet when thrown over. Any detected abnormality is noted and often reduces the total score (Manoharan *et al.,* 2004). The score is correlated to broiler performance.A positive correlation is between the scores and one week mortality has been suggested (Tona *et al.*, 2004).

2.6.3 Navel Score

The navel quality of the chick is another crucial parameter that is measured. It is one of the scoring parameters related to the day old chicks' survival. Most parameters that have been considered in the Pasgar and Leuven scoring systems have been highly related to the quality of the navel area in relation to the amount of withdrawn yolk and to the chicks 'activity (Fasenko and O'Dea, 2008). Well-developed chicks have clean and totally closed navels but when incubation conditions are not optimal and the chicks are poorly developed most of them have badly closed navels, black buttons or threads on their navels (Lourens *et al.*, 2006). Inaccurate navel development and degree of yolk sac internalization have the highest incidence within the hatcheries and thus could be the parameter of importance in the chicks' growth (Tona *et al.*,

2005). A badly closed navel risks contamination that would lead to yolk infection (Fasenko and O'Dea, 2008). Chicks with unhealed navels perform less efficiently than chicks with a healed navels and also there is a direct correlation between unhealed navels and yolk sac retention (Kenny and Cambre, 1992; Spears 1996; Crespo and Shivaprasad, 2003). In severe cases navels could lead to systematic disease (Pullorun disease, Newcastle disease and Bronchitis) and later death (Crespo and Shiaprasad, 2003). The physiological explanation for this occurrence has not yet been fully explained but the correlations of the yolk sac infection (omphalitis) studies show that elevated temperatures of over 38^0C affects the developments of the yolk stalk (Barri, 2008). Chicks with closed navels are considered to be of high chick quality since they are less prone to first week mortality (Meijerhof, 2003). Navel development problems have been mostly associated with incubation conditions such as high incubation temperature and humidity (Deeming, 2000b).

2.6.4 Growth Parameters

Some of the measurement done in day-old chicks includes body weight and body length (Gonzalez *et al.,* 2003). These have been found to be fast, repeatable and non-destructive methods of measurement (Molenaar *et al.,* 2008). Chick length is the distance from the beak to the toe measured by elongating the bird from the tip of the beak to the tip of the middle toe. It is considered a better indicator of final body weight than day old weight (Hill, 2002; Wolanski *et al.,* 2007; Joseph *et al.,* 2006 and Lourens *et al.,* 2005). Chick length at hatch is an evidence of embryonic development and utilisation of yolk (Elmehdawi, 2013). Therefore making it a useful tool in the measurement of embryonic development and chick growth potential (Wolanski *et al.,* 2007). The relationship between the initial weight at hatch and the 7-day weight of the bird can predict the birds performance at the initial stages of development (Gonzalez *et al*., 2003). But the hatchling's body length is the best parameter to predict the performance of the broiler chick than chick weight with the gender of the chick in mind (Barri, 2008). However if the nutrient is present in the intestinal lumen, utilisation of the residual yolk whose contents supply the substrate for the mucosal epithelium development is progressed faster (Uni *et al.,* 1998).

2.6.5. Yolk Free Body Mass

The chick without the residual yolk sac is a good index of chick progress, thus the determination of chick quality (Geidam *et al.,* 2003). In newly hatched chicks the residual yolk sac serves as sources of nutrition till external feeds intake begin. The yolk sac contents play the same role as that of colostrum in mammals; therefore its utilisation is essential to the birds' future, vitality and health (Mikee *et al.,* 2001). However, taking the yolk free body mass is an intensive and destructive method which makes it unsuitable for field evaluation (Geidam, 2003).

2.6.6. Residual Yolk Sac

At the time of incubation the poultry embryo metabolizes yolk lipids through β- oxidation pathway to access the energy needed for embryonic growth and development. The oxygen needed for the metabolic processes and excrement of lipid catabolism (heat and carbon dioxide) are sipped into the eggshell. After utilization of the lipid, the metabolic process changes when the neonate starts to pip (O'Dea *et al.,* 2004). The residual yolk sac is the only extra-embryonic membrane available during the early post-hatch period and it has been shown that alongside exogenous feed are very critical to the development of the digestive system and enzymes (Gonzalez *et al.*, 2003). In the process of hatching the yolk is utilized by the chick either by inner layer of its contents into circulation or by transportation through the yolk stalk into small
intestine.

The residual yolk is usually utilized within 4 days after hatching (Noy and Sklan, 2002).That is where nutrients is supplied to chicks within the first 72 hours after hatching. Two paths can be identified where yolk is utilised in the post-hatch phase. In the first phase, there is direct transfer of nutrients into the circulatory system and the second occur via the yolk stalk into the small intestines (Noy and Sklan, 2002). Nitsan *et al.* (1991) showed that the yolk sac content assists with 50% and 40% of the energy and protein on day 1 after hatching and 2% and 6% at day 4 after hatching respectively. Other researchers have also agreed that the yolk sac content supplied enough energy and protein to nourish the chicks for the next three days after hatch (Uni *et al.,* 1998). Fat was believed to have been imbibed from the yolk sac easier than glucose immediately after hatching. Again introducing hatchling to feed early improves the yolk sac absorption in the chicks (Noy and Sklan, 1995).

When chicks are moving from embryonic stage depending on the yolk to external dependence they will undergo metabolic dependence which includes increase secretion of digestive enzymes from the pancreatic sources and uptake processes to cause the chicks to have the right quantities of nutrients (Noy and Sklan, 1999). Noy and Sklan (1996) observed enzymes in the pancreas on the intestine during the later stage of embryonic growth. Its secretion of pancreatic enzymes per gram of feed intake changes meagerly after the fourth day (Uni *et al.,* 1996), and the ability of starch, protein, and fat to be digested was pegged at 85, 78, and 87%, respectively (Noy and Sklan, 1995). Also according to Hamidu *et al.*, 2007 wet yolk sac is not affected by the breeder strain however with increase flock age the yolk sacs increased. Peebles *et al.* (2001) indicated that broilers age from 26 to 31 wk and from 31 to 35 wk their yolk weight also increased. Suarez *et al.* (1997) reported a higher percentage of yolk in the older flock (59 wk) than the younger flock (29 wk). The hatching eggs components are also affected by egg size. Smaller eggs tend to have bigger yolk than larger eggs from the same age of hens (Vieira *et al.*, 2005).When there is a reduction in yolk sac proportion, this could affect the supply of lipids which produces about 90% of the energy to cause the embryo to grow well and to repair its tissues (Lekrisompong,2005).

Hatched chicks can rely on the residual yolk sac, although the use of the yolks is retarded when they are fasted (Vieira, 1999). The development of the gastrointestinal system is stunted under fasting conditions, and this may be related to the retarded utilisation of the yolk (Dibner, 1999). When there is a delay in maturation of the enzymatic system that control the process, which is caused by slow metabolism (e.g. the deiodination system and the activation of the T3 pathway), this will cause a retardation in the normal function of the immune system. Furthermore, the uptake of IgG, provided by the yolk, during the first day after hatching will also be slower (Dibenr, 1999). As chicks are hatched with eyes opened and leave nest as soon as possible, they will forage for feed almost immediately after hatching and begin to grow, whereas holding them without feed results in decreased body weight and a decrease in the overall performance of the broiler (Noy and Sklan, 1999).

CHAPTER THREE

3.0 MATERIALS AND METHOD

Two studies were conducted. The first study was a survey on the hatcheries across Ghana-in the Ashanti and Brong-Ahafo Regions(they were chosen because most of Ghana's hatcheries were concentrated in these Regions) to determine inventory of human resource strength and qualification, hatchery output, capacity of operation, availability of parent stock, common hatchery practices maintained to increased chick quality, day old chick production and market outlets, rates of chick mortality, distance of hatcheries from breeding farms, how many hatcheries imports eggs to hatch, what type of incubators and incubation system are used and whether hatcheries provided any follow-up on farms that take chicks from them. In addition, the study determined which hatcheries take eggs from outside to hatch and sell. The second study involved attachment with two major hatcheries in Ghana to monitor three batches of their production chain in the hatchery.

3.1 EXPERIMENT 1: Survey

3.1.1 Location and period of study

The survey was conducted from 1st April to 30th April, 2014 throughout the Ashanti and BrongAhafo Regions. The districts surveyed include: Atwima Kwanwoma, Atwima Nwabiagya districts, Offinso, Kumasi Metropolitan and Dormaa Municipalities. There are nine hatcheries in these regions. However, eight of these hatcheries are operating actively. The following hatcheries are located in the Ashanti Region Akate Farms and Trading Company Limited,

Akropong Farms Limited, Darko Farms Company Limited, Mfum Farms, Chicks and Chicken, Top man Farms, Asamoah and Yamoah Farms, Bamfo Farms while St Charles Farms is the only hatchery in the Brong-Ahafo Region.

3.1.2 Sampling size and sampling technique

The sampling size is all active hatcheries in both the Ashanti and Brong –Ahafo Regions of Ghana. These regions were chosen because of the concentration of poultry farms and hatcheries in these areas. The technique used was the purposive sampling.

3.1.3 Study Population

The study population was those actively operating hatcheries in the Ashanti and Brong –Ahanfo Regions.

3.1.4 Instrumentation

Questionnaires and interviews schedules were used to gather information for the study. Most of the questionnaires were given to the hatchery managers to fill and later collected however some preferred to be interviewed. All of the managers were contacted in their various offices and the questionnaires were administered. Information ascertained included the hatchery types (small, medium and large scale), capacity of operation presently, maximum capacity of hatch per incubation, rate of hatching, percentage of incubator capacity utilised, type of incubator used, the price of each day old chick, number of farms receiving chicks from the hatchery, number of workers (trained or untrained), maintenance parent stocks. The responds were collated and sorted out according to the answers provided.

3.1.5 Statistical analysis of survey data

For the survey, data collected were transformed into percentages.

3.2 EXPERIMENT 2: Performance study from hatcheries

3.2.1 Location and period of study

The second experiment took place from 1st May 2015 to 30th June 2015. This portion was divided into two: Trial 1 took place at Akate Farms and Trading Company Limited (Hatchery A) while Trial 2 took place at Darko Farms Limited (Hatchery B). In each hatchery, data monitoring took place earlier at the hatchery followed by a laboratory component at the Microbiology lab at the

Department of Animal Science, KNUST. Eggs obtained from each of the two hatcheries were incubated at the hatchery and monitored for quality of eggs received, egg weight before storage, egg weight before incubation, temperature of storage room, relative humidity of storage room, egg storage length, temperature of eggs before storage, chick weight. At hatchery A, Cobb broiler chicks were used while at hatchery B, Hubbard broiler chicks were used.

3.2.2 Sampling size and techniques

The sampling size was all active hatcheries hatching broiler birds in the both the Ashanti and Brong-Ahafo Regions and the technique used was the purposive.

3.2.3 Study population

The study population was all hatcheries hatching eggs for the poultry community.

3.2.4 Process of Incubation

At both hatcheries, three consecutive batches of a production chain were monitored. At the breeder farm, eggs were collected, sorted to make sure they were clean, not dirty, not cracked, small, not very large, and not poor shell. The clean eggs were stored in trays and transported to the hatchery. And their weight before storage was recorded. Upon receipt at the hatchery, eggs were placed in setter trays. The eggs were sent to the storage room close to the receiving room and stored. The temperature, relative humidity, and days of storage were recorded. The eggs were placed on setter trays in setter trolleys and sorted again this time to replace possible cracked eggs and to check the position of the eggs (eggs are set with blunt side up). The loaded setter trolleys were moved into the fumigating room after which a basin with potassium permanganate (rate of $20g/m^3$) was put in the room. Liquid formalin ($30ml/m^3$) was added and reaction started immediately. The door to the fumigation room was closed tight immediately to avoid inhalation by staff**.** After 10- 20 minutes the fan in the room was switched on from the outside. Doors were opened to ventilate the room for about an hour. The trolleys were moved to the setter room. After disinfection, the hatching eggs were prepared for incubation. The machine was checked for proper functioning, temperature, and relative humidity were set and recorded. The setter trolleys were transferred to the setter room. Candling began on the day of transfer to carry out an analysis of clear eggs. Candling was done by exposing trays of eggs to light (usually a table in which a fluorescent light is fitted in) to show the infertile eggs so that they could be removed. Eggs were transferred to the hatcher baskets. The hatcher was filled completely to start hatching. During the hatching process, liquid formalin was placed in the hatcher for evaporation to give the chicks their yellow colour. Before chicks were removed on day 21, the chick room was prepared for chick handling by recording the temperature, relative humidity and proper arrangement of transfer boxes. Trolleys were taken out individually and chicks were sorted for clean and healthy ones without any deformities. They were counted individually, labeled and placed in the appropriate transfer boxes. On the hatch day, all equipment and rooms were cleaned and disinfected.

3.2.5 Laboratory analysis

After each hatch sample of chicks (n=120) were transported to the Department of Animal Science, KNUST for dissection and analysis. Upon arrival at the lab, the chicks were tagged and individually weighed with an electronic scale (Tree Electronic precision scale, model: HRB203). The following parameters were then taken: live weight, chick length, shank length, navel scoring following the Tona or Pasgar scoring system as described earlier. The chicks were then dissected by first euthanizing them by cervical dislocation after which the residual yolk sac was carefully taken out. The components recorded as part of the carcass analysis are yolk free body mass after removing the residual yolk sac, residual yolk sac and intestine. All the components were weighed, wrapped in an aluminum foil and placed in an oven then their dry matter taken.

3.2.6 Chick measurements

3.2.6.1 Chick length and shank length

The chick was stretched over a ruler and the chick length was measured from its beak to the longest toe in centimeters. With the shank length, a caliper was held between the footpad and the hock and then carefully transferred to a rule and the reading taken as shown in plate 2 (c).

3.2.6.2 Naval scoring

Each chick was then visually and subjectively scored for condition of naval abnormalities based on a three observable naval scoring variables (Tona *et al.*, 2004) as shown in plate 2 (a)and (b). According to Tona *et al.*, (2004) a thread navel is less than 2mm, above 2mm indicates big navel button and a clean button cannot be felt which means its zero. The conditions were inspected critically for clean, thread hanging from the navel and big navel button.

3.2.6.3 Carcass weight

Each of the chick was carefully and painlessly killed through cervical dislocation, the dead chick was dissected with the use of a scalpel and the residual yolk sac removed and weighed. The weight of the intestine (plate 2 d) was also taken and placed back in the lifeless body. The weight of the chick without the yolk sac (plate 2 d) was determined as the yolk free body mass. The yolk free body mass and the residual yolk sac were individually wrapped in a weighed aluminum foil and place in an oven at 65 ^{0}C for 4 days to find the dry matter. All the dissected parts (wet and dry weights) were expressed as percentage of the initial chick weight.

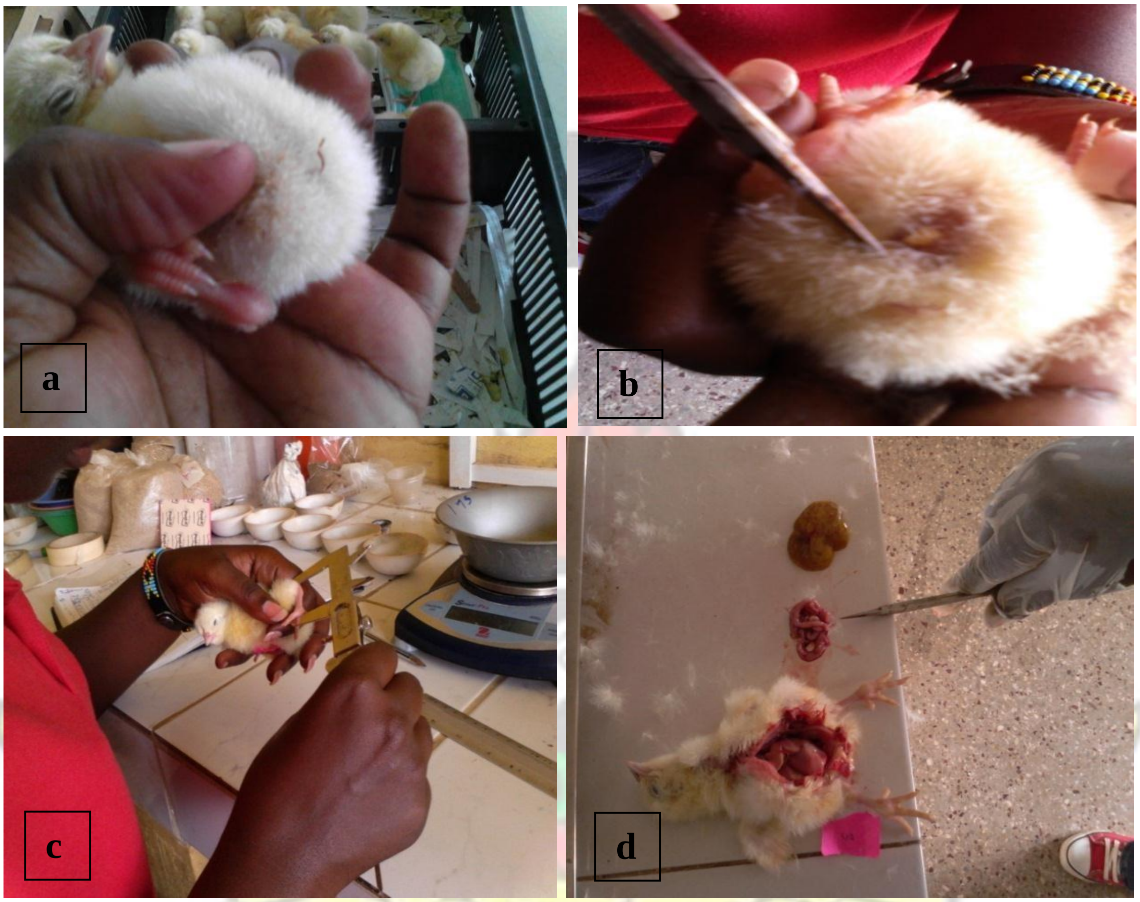

Plate 2: Various ways of assessing chick quality displayed (**a, b**)show the navel score of chicks(**c**)show the dissected chick with the yolk sac from the top, the intestine in the middle and the labeled chick without intestine and yolk sac(**d**) using the veneer caliper measuring the shank length also in the picture is the electronic scale.

3.2.7 Data Analysis

For performance experiments, the data was analyzed with the Generalized Linear Model procedure of SAS version 9.4® at $p<0.05$. Here significant differences were observed, the least squares means were separated by the pdiff procedure of SAS (SAS Statistical Institute, 2012).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Experiment 1: Inventory of major Hatcheries in Ghana

4.1.1 Major hatcheries in Ghana and their performance measurement

The data collected showed that there are 8 hatcheries in Ghana operating actively in hatching broiler or layer chicks or both (Table 1). These hatcheries include Asamoah and Yamoah Farms , Akate Farms and Trading Company Limited, Akropong Farms Limited, Bamfo Farms, Darko Farms Company Limited, Mfum Farms, St Charles Farms and Top man Farms.

Table 1 :Major hatcheries in Ghana and their performance measurements

Hatchery	Years in operation	Hatching Capacity (eggs)	Utilization (month)	Utilization (%)	Type of incubator	System of Incubation
A	20	120000	10000	8.33	Chick Master	Multi-stage, single-stage
B	40	45000	9000	20.00	Buckeye	Multi-stage
C	33	38000	26000	68.42	Asefac	Multisystem
D	15	420000	60000	14.29	Petersime, Westing, Beckier	Multisystem
E	20	400000	-	-	-	-
F	16	120000	10000	8.33	Buckeye, Petersime	Multisystem
G	11	115200	69120	60.00	Petersime	Multisystem

NB: For confidentiality, these hatcheries have been identified by letters such as A,B,C,D,E,F and G which represents names of the hatcheries. Spaces were as a result of hatcheries refusing to give out these information

Some of them have been in the business for well over 30 years. Therefore, their machines are very old which have seen no replacement for a long time, that they may not be meeting modern incubation standards anymore. This can present a lot of problems to hatchery managers who would struggle to make good production output. Only two of these hatcheries were operating at 60% and 68% of their full capacity based on the quantities of eggs that can fully fill available incubator space (Table 4.1). The rest were operating at 8, 14 and 20 percent of their capacity. This goes a long way to support Ghana Business News (2013) assertion that most of our hatcheries are producing below 60%. The smallest hatchery had a capacity of 38,000 egg incubator space while the largest hatchery 400000 eggs incubator space. The type of incubators used by all the hatcheries includes Chick Master, Buckeye, Asefac, Petersime, Westing and Beckier while the major incubation system practiced was the multi-stage incubation system while only one hatchery having a single stage incubator. The incubators used by all the hatcheries are different from one hatchery to the other. However, almost all the hatcheries claimed to practice the multistage incubation system, where eggs of more than one embryo age are present in the incubator at the same time (Hamidu *et al.,* 2007). However, a typical multistage incubation system would not mix eggs on a single setter rack but multiples racks are moved along as new eggs are pushed into the incubator. Even though this incubation system is common it is evident that, it presents its own problems which are not common knowledge to Ghanaian hatchery managers. Single stage incubation system against the multistage system is the current and probably suitable standard incubation system (Hamidu *et al.,* 2007). This could be because of its advantages ranging from improved day old-chick quality, improved hatch rates and fewer cull birds which then provide viable, well hydrated and healthy birds from day one to the time they grow. This also affects the mortality in a positive way particularly in the first week, growth rate and in feed conversion. The variation in the types of incubators/setters used in Ghana could have its own bigger problem that may have added to already ailing Ghanaian poultry industry due high feed cost that account for about 70 to 80% (Benabdeljelil *et al.*, 2001) of current production cost (Durunna *et al.*, 1999). Since it will be difficult and expensive to engage a good incubation expert to monitor the performance of the various hatcheries as the operations and system maintenance strategies of each machine differ. According to information found at the

Poultry Site (2014) currently, Ghana's poultry sector is having challenges which include hatcheries operating below expectations due to unrestricted trade liberalization that permits the liberalisation of avian product to be imported. For a country that could produce 90 per cent of its poultry needs as of 1993, according to MoFA figures (MoFA, 2013), Ghana can now produce a trivial 10 per cent of its poultry products and also the amount of money channeled into the importation of poultry product increases considerably from year to year.

4.1.2. Maintenance of high performance of hatcheries

Table 2 presents the results of inventory of Ghanaian hatcheries and steps to maintain high performance. Out of the 7 hatcheries interviewed, only 3 of them provided basic training to all their staff. An additional 3 hatcheries provided training for about 40 to 70 % of their staff (Table 2). These training were however in-service meaning the experience of older hatchery personnel was passed on to the new ones. This supports Pas Reforms (2015) assertion that whether for new employees or as a routine for existing hatchery personnel, training motivates people to do a great job. Two hatcheries indicated they had staff that received training from the manufacturers of their machine which was more important to help them understand the operation of the incubators. This is vital because it is important for employees to understand what they do and why they do it and not just to follow Standard Operating Procedure (SOP's) (Pas Reforms, 2015).

Table 2: Inventory of Ghanaian hatcheries and steps to maintain high performance

Hatchery	Hatchery workers	Trained Workers	Training (%)	Place of Training	Manufacturer Training	Association
A	5	2	40	In-service	No	Ghana Poultry Farmers
B	5	5	100	In-service	No	Ghana Poultry Farmers
C	4	4	100	In-service	No	Ghana Poultry Farmers
D	20	15	75	In-service	Yes	Ghana Poultry Farmers
E	6	4	67	In-service	Yes	Ghana Poultry Farmers
F	5	5	100	In-service	No	
G	15	3	20	In-service	No	Ghana Poultry Farmers, World Poultry Science

NB: For confidentiality, these hatcheries have been identified by letters such as A,B,C,D,E,F. and G which represents names of the hatcheries.

The survey results from Table 2 reveal that 6 of the hatcheries were associated with the Ghana Poultry Farmers Association and one was additionally a member of the World Poultry Science Association. Such association is important to help pass appropriate knowledge and new information to hatchery personnel. In agreement Pas Reforms (2015) encourages that to have a good hatchery manager or employees, professional development must be involved in their work in order to grow into their job and build experience, while staying up-to-date by reading relevant articles and attending seminars. In addition hatchery management training is paramount for managers to share ideas and experiences with specialists and managers from other hatcheries. Mabbett (2012) has reported that in successfully managing a hatchery for long, the right tool and technical know- how is needed to monitor the requirement of the egg and developing chick including having workers trained properly to measure, and monitor parameters in the hatchery.

In spite of the advances technologies in current incubation industry, some of the best tools available to workers at the hatchery are their ability to observe and use their instincts to figure out issues of the sight, hearing and smell. Prompt identification of any problems will depend on the individual's ability to recognize some warning signs and accepting that there is a need to investigate (Mabbett, 2012).This is where the new technologies learnt is made useful to the worker to add value by applying them in the whole incubation processes. However, the engagement of veterinary service after hatcheries problems have escalated to full level yolk sac infections cannot cure the diseases of the chicks leading to high mortalities. Proper training of hatchery staff is one of the success paths of a hatchery (Pas Reform, 2015).

4.1.3 Quality assurance of hatcheries

Table 3 presents the results of steps toward quality assurance and how to reduce low performance in the hatcheries. The inventory showed that five hatcheries kept their own parent stock while the rest buy or depended on farmers who contracted them with eggs to be hatched for them. The larger number of parent flock were layers, indicating a very low attention on broiler production in Ghana, this is in support of Ghana Poultry Report Annual (2013) that the demand for layers from hatcheries is over 80 percent of total capacity. However, the research differs from Ghana Poultry Report Annual (2013) stipulation that only three hatchery companies maintained their own broiler parent stocks with the others importing fertile eggs or depending on farmers to bring in their eggs to hatch . The main breed kept by these hatcheries was the Lohmann with other hatcheries complementing this with other breeders which may be in small numbers. Major hatchability challenges reported in the eggs given to these hatcheries were dead in shells, unsealed navels, twisted beak, wet chicks, and blind chicks among others.

Table 3: Inventory of Ghanaian hatcheries and steps toward quality assurance and reduce low performance

Hatchery	Own parent Stock	No. broiler parent stock	No. layer parent stock	Type of Breed	Storage duration (days)	Storage temperature (°C)	Hatch Challenges
A	Yes	6000	-	Lohmann	6-7	16-17	fore-hatch, dead in shells
B	Yes	-	-	-	6-7	20	-
C	No	-	-	-	4	-	navel, unsealed blind chicks
D	Yes	10000	20000	Hyline, Lohmann, Harco, Cobb	4-7	18.5-19	-
E	Yes	-	-	-	7	-	-
F	No	-	-	-	4	-	-
G	Yes	10000	55000	Lohmann, Boman heavy	4	17	twisted beaks, wet chicks, navel

NB: For confidentiality, these hatcheries have been identified by letters such as A,B,C,D,E,F,and G which represent the names of the hatcheries. Spaces were as a result of hatcheries refusing to give out some of this information

According to the hatcheries, they store eggs not more than 7 days and storage temperature did not exceed 20°C. According to Tona *et al.* (2003) the duration of storing eggs affects the chicks thus before incubation. The effect of storage has both positive and negative implications depending on how long it is stored (Reijrink *et al.*, 2009). Wilson (1997) reported that the reproductive performance of the parent stock is important for the hatchery to determine the amount of saleable chicks at a minimal cost, it is important that uniform chicks be attained to get better production. It is important that the setters and hatchers attain an optimum level so the uniformity of chicks does not suffer and the hatching time could take a longer time there by affecting hatchability. According to Wilson (1997) many factors affect hatchability these include egg size and age of breeders, season of the year and nutrition, egg handling and storage, temperature and humidity throughout the incubation and hatching period.

4.2 Experiment 2 -Performance study

4.2.1 Trial 1-*Hatchery A*

Table 4: Hatch performance of broiler chicks hatched from three different batches in a local hatchery in Ghana.

Batches	Chick weight (g)	Chick length (cm)	Shank Length (cm)	Naval Score (cm)	Intes-tine weight (g)	Wet YFBM (g)[4]	Dry YFBM (g)[5]	Wet RYS (g)[6]	Dry RYS (g)[7]
(24wk)[1]	43.25^{a}	18.34^{b}	2.93^{a}	2.05	2.46^{b}	36.72^{a}	20.39^{a}	5.59^{b}	2.54^{a}
(25wk)[2]	43.50^{a}	18.5^{2345b}	1.57^{b}	2.05	4.21^{a}	37.69^{a}	10.30^{c}	6.57^{a}	2.60^{a}
(26wk)[3]	40.16^{b}	19.25^{a}	1.63^{b}	2.05	2.49^{b}	34.97^{b}	13.36^{b}	2.34^{c}	1.52^{b}
SEM[6]	0.77	0.12	0.09	0.12	0.06	0.59	0.83	0.20	0.24

[1, 2, 3] Indicate first, second and third batches respectively of the eggs collected before hatching

[2] Wet Yolk Free Body Mass

[3] Dry Yolk Free Body Mass

[4] Wet Residual Yolk Sac

[5] Dry Residual Yolk Sac

[6] Standard error of means belonging to the different treatments within the various hatch performance

*P*value[1]	0.0059	<0.0001	<0.0001	0.9998	<0.0001	0.0076	<0.0001	<0.0001	0.0032

Superscripts ($^{a-c}$) indicates significant difference among means in the same column (P<0.05).

wk) with the third batch (26wk) recording the lowest value. The chick weight was significantly (P<0.01) different. The flock ages 24 to 26 weeks can all be considered young maternal flock ages so it is not very clear why such differences in the parameters measured were observed. All the chick weights recorded were lower than recommended average day old chick weight of 48g for a uniform sized flock (Cazaban, 2005). The lower chick weight means that these chicks may have been hatched from lower weight eggs and therefore the chicks will need better brooding management in order to reduce first week mortality (Yassin *et al*., 2008). There was significantly (P<0.01) short chick length in the first and second batches compared to the third batch of hatch. Additionally chick length at hatch could be affected by the breed of broiler. This is in agreement with Alsobayel *et al*. (2013) whose study shows that chick length at hatch was significant (P< 0.01) which was affected by the breed and breeder age. However, Willemsen *et al*., 2008 asserts that chick length was influenced by breeder line of breeder age.

Chick length was significantly different (P<0.05). The significance of chick length is a positive attribute that the chick is absorbing yolk sac and converting it to weight of YFBM and consequently the length of the chick (Meijerhof, 2006). The chick length is one of the most

[1] *P*-value of columnar means

Table 4 presents the hatch performance of broiler chicks hatch from three different batches in a local hatchery. The chick weight were similar in the second batch (25wk) and the first batch (24 important parameter of determining a good chick from the masses. Chick length is important for a good chick quality.

The shank length which indicated an increase in the second batch (24wk) and third (26wk) batches. The second batch having the lowest value. Shank length was highly significantly
($P<0.01$) different. The length of storage tends to affect later the changes which occur in the formation of the shank length. In agreement with this current study, Servet and Paul (2003) stipulate that egg stored under very cold condition have their chicks producing significantly higher shank length than those stored under ambient temperature. Since the conditions are optimal it means that the shank was a means of determining a good chick quality.

However, navel score was not significantly ($P>0.05$) different. Omphalitis and mortality are associated navel conditions on chick survivability. Generally boilers with navel conditions are regarded as inferior (Fasenko and O'Dea, 2008). Chicks with navel conditions could be detrimental to their growth especially later on .But in their early stage there is not much difference between chicks with bad navel condition and chicks with normal-appearing navels.
Even though in this study, there was not much significance.

Intestine weight recorded similar significance in the first (24 wks) and third (26 wks) batches but a higher value was recorded for the second batch (25wks). This Mahmoud and Edens (2012) supports this when in their research broiler chicks had feed access delayed. When feed was given, chicks from the feed delayed group indicating an enormous increase in small intestine weight relative to body weight, surpassing ($P < 0·05$) the control groups across all flock ages. The similarity between the first and third batches could be due the storage room conditions together with poor feeding could affect the condition of these batches.

Wet YFBM recorded similar significance with both batches (24and 25 wk) while the third batch (26wk) recorded the least. Wet YFBM was highly significantly different($P< 0.01$). This was due age of the breeding flock which are much younger and producing a less heavier eggs which will in effect produce less heavier chicks. This agrees with Nanqsuay *et al* (2011) who indicated that significant relation existed between breeder age and egg size was found for yolk-free body (YFB) mass only at day 7. Until the fourteenth day of incubation, eggs from the old hens yielded better YFB mass than did eggs from the young hen.

Dry YFBM had a change in the values where the first batch recorded the highest followed by the third batch and the second batch recording the lowest. This was highly significantly different ($P<0.01$).The ages of the breeder flock tend to have a bearing on dry YFBM. This is contrary to what Nanqsuay *et al.* (2011) asserts that dry YFBM of chicks from the old (53 wk) hen was higher than day old chicks from the young (29wk) hen. However, it proves otherwise in this study where young flocks are used and yet have a high dry YFBM.

Wet RYS recorded the highest value with the second batch (25 wks) followed by the first batch (24 wks) and the third batch recording the lowest value. The same pattern occurred in the dry YS where the second batch recorded a higher value followed by the first batch and the third batch recorded the lowest value. The wet and dry YS were significantly differently at (P<0.01). RYS whether dry or wet is well absorbed when feed is made available to chicks in time. Mahmoud and Edens (2012) supports this when in their research broiler chicks had feed access delayed. It was noticed that chicks from the older hens imbibed more yolk in the within two days with no feed delayed (FD) effect. In relation to this result, the chicks which were not fed early affected the absorption of the wet RYS therefore recording significance in all the ages of irrespective of the age. With the dry RYS the significance of the batch one (24 wks) and two (25 wks) were similar but the third batch indicated a slightly lower significance.

Table 5: Percentage results of the different batches of hatched chicks

Batches	% Intestine Weight[4]	% Wet RYS[5]	% Dry RYS[6]	%Wet YFBM[7]	% Dry YFBM[8]
(24 wk)[1]	5.71[c]	12.94[b]	5.77[a]	82.44	47.13[a]
(25 wk)[2]	9.73[a]	15.07[a]	5.91[a]	86.85	23.86[c]
(26 wk)[3]	6.22[b]	5.70 [c]	4.13[b]	87.25	33.14[b]
SEM[9]	0.16	0.65	0.50	1.72	1.87
P-value[10]	<.0001	<.0001	0.0287	0.0979	<.0001

Superscripts ([a-c]) indicate significant difference among means in the same column (P<0.05).
[1, 2, 3] indicate first, second and third batches respectively of the eggs collected before hatching
[4]% Intestine weight = (Intestine weight /chick weight)*100
[5]%Wet Residual Yolk Sac= (Wet Residual Yolk Sac/chick weight)*100
[6]%Dry Residual Yolk Sac= (Dry Residual Yolk Sac/chick weight)*100
[7]%Wet Yolk Free Body Mass= (Wet Yolk Free Body Mass/chick weight)*100
[8]%Dry Yolk Free Body Mass= (Dry Yolk Free Body Mass/chick weight)*100
[9]Standard error of means belonging to the different treatments within the various hatch performance
[10]*P*-value of columnar means

The result of different batches of hatched chicks is presented in Tables 5. The percentage intestine weight value was highest in the second batch (25wk), the third batch followed and the first batch recorded the lowest value. Percentage intestine was highly significantly different (P<0.01). Age of breeder flock has an effect on intestine weight chicks. This is in line with Mahmoud and Eden (2012) research where chicks from the feed delay group showed an increase in small intestine weight relative to body weight when feed was made available, surpassing ($P < 0{\cdot}05$) the control groups across all breeder flock ages. Additionally, the structural measurements in the intestinal sections had higher rates in the chicks derived from the middle age breeder flock. Feed delay to newly hatched chicks from the young flock reduced intestines ($P < 0{\cdot}01$) length.

With the percentage wet RYS the second batch recorded the highest values followed by the first batch with the lowest value with the third batch (26wk) but with the dry RYS there was similar values recorded in first and second batches with the least values recorded with the third batch. Wet RYS were significantly different ($P<0.01$). RYS whether dry or wet is well absorbed when feed is made available to chicks in time. Mahmoud and Edens (2012) supports this when in their research broiler chicks feed access delayed. It was noticed that chicks from the older breeder flock took in more yolk in two days with no feed delay effect. When feed was given to the chicks, chicks from the feed delayed group showed an enormous increase in small intestine weight relative to body weight of the chicks, surpassing ($P < 0{\cdot}05$) the control groups across all breeder flock ages.

The percentage wet YFBM recorded a higher value in the third batch (26wk), the second batch (25wk) recorded a slightly lower value and the first batch recorded the lowest value. However the percentage wet YFBM was not significantly different ($P>0.05$).The insignificance of wet YFBM was contrary to Nanqsuay *et al.*(2011) work where at hatch, their chicks were heavier, longer and had higher wet YFBM. The differences could be due to the young nature of this research breeding flock. It could be conclude that Nanqsuay *et al.*(2011) had older birds as their breeding flock which in turn produced heavier chicks.

Percentage dry YFBM recorded first batch (24wk) followed by the third batch (26wk) and the least value recorded in the second week. Percentage dry YFBM was significantly different at (P<0.01). This could be due to the yolk weight .This is in line with Nanqsuay *et al.*(2011) who stipulates yolk weight increased with breeder age implying that large eggs will mean bigger albumen. Additionally, dry YFBM of hatchling from the old (53 wk) flock was higher than that of hatchling from the younger breeder flock.

Table 6 : Effect of the number of days on the various performances before hatch in a local hatchery in Ghana

Days	Egg weight before storage (g)	Egg weight before incubation (g)	Temperature of storage before incubation (^{0}C)	Relative humidity of storage before incubation (%)	Storage length (days)	Temperature of egg before storage (^{0}C)
1	62.10^{d}	61.48^{d}	16.00	75.00	4.00^{a}	22.55^{h}
2	66.87^{ab}	66.90^{a}	16.00	75.00	3.00^{b}	28.66^{g}
3	62.30^{cd}	62.03^{cd}	16.00	75.00	2.00^{c}	30.65^{e}
4	63.97^{bcd}	63.60^{bcd}	16.00	75.00	1.00^{b}	31.37^{d}
5	63.53^{bcd}	63.47^{bcd}	16.00	75.00	3.00^{b}	31.29^{d}
6	68.03^{a}	67.70^{a}	16.00	75.00	2.00^{c}	32.45^{b}
7	67.90^{a}	66.83^{a}	16.00	75.00	1.00^{d}	28.79^{g}
8	63.47^{bcd}	63.27^{bcd}	16.00	75.00	4.00^{a}	33.44^{a}
9	65.63^{abc}	64.73^{abc}	16.00	75.00	3.00^{b}	31.99^{c}
10	65.70^{abc}	65.53^{ab}	16.00	75.00	2.00^{c}	32.43^{b}
11	65.57^{abc}	65.57^{ab}	16.00	75.00	1.00^{d}	29.77^{f}
SEM[1]	0.83	0.77	-	-	0.00	0.13
P-value[2]	<0.0001	<0.0001	-	-	<0.0001	<0.0001

Superscripts $^{(a\text{-}h)}$ indicate significant difference among means in the same column (P<0.05).
[1]Standard error of means belonging to the different treatments within the various hatch performance
[2]*P*-value of columnar means

Table 6 above show the egg weight before storage recorded the highest value on the 6th day of storage with the respective decrease on days 7,2,11,9,10,4,5,8,3 and 1 recording the lowest value. Egg weight was significantly high at ($P<0.05$). Hatchery which has area for holding eggs is maintained at 65-70F and 75 % relative humidity. Storage condition for eggs to be hatched should be not be too long to affect hatchability (King'ori, 2011; Ipek and Sozcu, 2013). Eggs start to lose weight at every temperature it finds itself. It is therefore imperative that conservation of egg weight before storage should be the focus of the hatchery so as not to lose too much moisture obviously through its pores (Hamidu *et al*., 2010)

Egg weight before incubation showed the highest value on the 6th day with the respective decrease on the days 7,2,11,10,9,4,5,8,3 and 1 day recording the lowest value. Egg weight before storage was significant ($P<0.05$). The significance experienced was as a result of the kind of strain of broiler(Cobb) raised even though the age of breeders for the current study is younger yet not much difference will be seen in respect to the age. Alsobayel *et al.* (2013) supports this when a total of 1350 hatching eggs were sourced from commercial breeders Cobb, Ross 308 and Arbor Acres at 30-35,40-45 and 50-55 weeks of age,450 eggs for each breed age. Eggs for each age were randomly divided into three groups, 50 eggs in each, stored either for 0, 7 or 14 days, individually weighed before and after storage and incubated following usual hatchery practices. Arbor Acres and Cobb had statistically similar egg weight whereas Ross had significantly ($P > 0.05$) the lowest value. Old breeders and fresh hatching eggs had significantly ($P > 0.05$) the highest egg weight whereas young breeders and hatching eggs stored for 14 days had the lowest egg weight. Egg weight of Cobb was significantly ($P > 0.05$) the lowest at 30–35 and the highest at 40–45 weeks of age whereas that of Ross was significantly ($P > 0.05$) the lowest at 40–45 and 50–55 weeks of age. Cobb and Ross 308 were better strain to have a good weight.

The storage length saw increase on days 1 and 8 slight decrease on days 2,5.9 followed by days 3,6 and 9 with the least value recorded on days 4,7 and 11. The storage length was significantly ($P<0.05$) high. The storage length affects the development of day old. Goliomytis *et al.* (2015) agrees with this current study where in their experiment the effect of pre-incubation storage length of broiler eggs were conducted on hatchability on a day old chick quality and subsequent performance, a total of 360 hatching eggs were stored for 4,12 and 16 day prior to incubation. Hatchability and chick quality assessed at hatch, and growth performance were assessed during a 35 day rearing period. It was noticed that growth parameters which were affected were chick body weight and chick length.

The temperature of eggs before storage records higher value on day 8 with respective decrease on the following days 6,10,9,4,5,3,11,7,2 and 1 recording the lowest value. The temperature of eggs before storage was significantly ($P<0.05$) high. Temperature and oxygen stands as the two important incubation factors that are known to affect embryonic development (Lourens, 2004; Meijerhof,2009,Willemsen *et al.,* 2008).It should be noted that the optimal temperature is good for optimal embryo development, after hatch performance and good success during the period of hatching(Lourens *et al.,* 2005;Ipek and Sozcu,2013).

4.2.2 Trial 2-*Hatchery B.*

Table 7: Effect of storage length on the various performances before hatch

Storage length /Days	Egg weight before storage (g)	Egg weight before incubation (g)	Temperature of storage room (^0C)	Relative humidity of storage before incubation (%)	Temperature of eggs before incubation (^0C)	Temperature of eggs before storage (^0C)
1	55.39^{a}	55.28^{a}	20.00	38.00	25.87	32.27^{ab}
2	55.85^{a}	55.16^{a}	20.00	38.00	24.23	31.71^{ab}
3	55.78^{a}	56.54^{a}	20.00	38.00	24.12	30.07^{b}
4	56.51^{a}	56.03^{a}	20.00	38.00	24.42	32.02^{ab}
5	56.49^{a}	55.70^{a}	20.00	38.00	24.18	28.62^{c}
6	56.03^{a}	55.10^{a}	20.00	38.00	24.12	34.32^{a}
SEM[1]	0.22	0.58	-	-	0.59	1.56
*P*value[2]	0.0026	0.3211	-	-	0.2981	<0.0001

Superscripts ($^{a-c}$) indicates significant difference among means in the same column (P<0.05). [1]Standard error of means belonging to the different treatments within the various hatch performance
[2]*P*-value of columnar means

Egg weight before storage was significantly (P<0.05) higher. Egg weight before storage on day 4 followed by day 5,6,2,3 and the lowest value on day 1. Eggs start to lose weight at every temperature it finds itself. It is therefore imperative that conservation of egg weight before storage should be the focus of the hatchery so as not to lose too much moisture obviously throught its pores (Hamidu *et al.*, 2010, 2011).

Egg weight before incubation decreased significantly (P<0.05) and showed higher value on day 3 and a decrease on days 4,5,1,2 and 6. Its decrease in significance is due to the fairly younger ages of the breeders which mean that there would not be much weight loss since egg shell is thinker.

This agrees with Zakaria *et al.* (2009) who asserts that egg weight loss before and during incubation increases with advanced age of broilers' breeders due to deterioration in shell quality. Also Roque and Soares (1994) agree by indicating that egg weight percentage during or before incubation was higher for eggs produced by young breeders than that produced by older breeders.

Temperature of eggs before incubation recorded the highest value on day 1 followed by days 4,2,5 as days 3 and 6 recorded the least values. Interactions in the environmental temperature resulted in changes in embryo growth than with humidity-related changes, especially where mortality and malformation were present (Noiva *et al.*, 2014). It is important that the right temperature is maintained for eggs to reduce these embryo development mortalities. Lourens *et al*. (2005) concludes that when the temperature of the eggshell reached 38^{0}C at incubation a better embryo development and after hatch performance were higher. Consistent changes in egg shell temperature can result in negative impact body organs and the quality of chick being produced (Wilson, 1991).

Temperature of eggs before storage was higher on day 6 than the subsequent days which recorded decrease in value on days 1,2,3,4, and 6 respectively. Temperature of eggs before storage showed no significance at (P>0.05). Pre-incubation egg holding is important. Changes in the temperature could affect development stage at oviposition (Decuypere and Michels,1992).

Table 8: Effect of age in the various performances before hatch in the local hatchery.

Age/ Weeks	Egg weight before storage (g)	Egg weight before incubation (g)	Temperature of storage room (^{0}C)	Relative humidity of storage before incubation (%)	Temperature of eggs before incubation (^{0}C)	Temperature of eggs before Storage (^{0}C)
28	52.53^{e}	52.07^{c}	20.00	38.00	26.14	31.40^{a}
29	54.34^{d}	53.68^{bc}	20.00	38.00	25.86	32.47^{ab}
30	55.28^{c}	54.67^{bc}	20.00	38.00	25.20	32.35^{ab}
31	56.40^{bc}	56.11^{b}	20.00	38.00	23.19	35.32^{a}
38	55.23^{bc}	54.80^{bc}	20.00	38.00	22.99	27.55^{b}
39	56.57^{a}	55.96^{b}	20.00	38.00	23.29	31.40^{b}
40	58.25^{a}	58.65^{a}	20.00	38.00	24.63	31.33^{b}
41	59.47^{a}	59.13^{a}	20.00	38.00	24.62	30.16^{b}
SEM[1]	0.30	0.77	-	-	0.79	1.17
P-value[2]	<0.0001	<0.0001	-	-	0.0005	0.0087

Superscripts ($^{a-e}$) indicates significant difference among means in the same column (P<0.05).
[1]Standard error of means belonging to the different treatments within the various hatch performance
[2]*P*-value of columnar means

Egg weight before storage was significantly different at (P<0.05) which also show the highest value on age 41 followed by ages 40,39, 31,30,38, 29 and age 28 having the least. Egg weight is significantly affected by the relationship that exist among flock age and egg size(Ulmer-Franco *et al.,* 2010;Tona *et al.,*2004).Generally eggs can be hatched irrespective regardless of egg size or later irrespective of the flock age(Ulmer-Franco *et al.,* 2010)

The temperature of eggs before incubation recorded the highest value on age 28 which was followed by ages 29,30,40,41,39,31,and 38. It was slightly significantly (P>0.05) different. Temperature just like humidity is an important factor affecting embryonic development. Delay in and reduction could impact negatively on the embryo development. This is in line with Noiva *et al.* (2014) where in their results parameters observed throughout embryonic development shown to be most affected were albumen-weight to egg weight ratio, yolk weight to egg-weight, mortality rates. Significant changes occur in the albumen –weight to egg –weight ratio (AR) and yolk–weight to egg-weight (YR) throughout incubation. This was due to the delay and reduction temperature manipulations in the hatcheries.

Temperature of eggs before storage was highest on age 31 which was followed by 29, 30.28,39,40,41 and the least value on age 38.Temperature of eggs before storage was the least significance($P<0.05$). Temperature is the first and fore most factor that influences conditions in during incubation that tends to affect the embryonic development (Decuypere and Michels, 1992). According to Nicholson *et al.* (2012) heating hatching eggs to obtain the incubation temperature before storage is a way to allowing embryo development to go on so that embryo could develop to the point of improving survivability after long storage and also carry on repairs in the cell (Dymond *et al.* 2013)

Table 9: Hatch performance of broiler chicks in relation to parents of different ages

Age/ Weeks	Chick weight (g)	Chick length (cm)	Shank length (cm)	Naval score (cm)	Intes - tine weight (g)	Wet RYS[1] (g)	Dry RYS[2] (g)	Wet YFBM[3] (g)	Dry YFBM[4] (g)
28	33.65[c]	18.56[c]	1.39[c]	2.25[ab]	1.25[b]	2.43[b]	1.68[b]	30.93[c]	22.91[c]
29	38.90[ab]	18.51[c]	1.43[bc]	1.90[ab]	1.19[b]	3.38[b]	2.98[a]	34.32[b]	25.13[abc]
31	37.70[b]	18.60[c]	1.46[bc]	2.30[ab]	1.37[a]	3.75[a]	3.00[a]	34.20[b]	23.82[bc]
39	40.45[a]	18.97[b]	1.50[a]	2.60[a]	1.22[b]	3.33[a]	2.57[a]	35.71[a]	25 .94[ab]
41	41.00[a]	19.48[a]	1.55[a]	1.80[a]	1.57[a]	4.16[a]	3.35[a]	36.28[a]	26.66[a]
SEM[5]	0.71	0.11	0.03	0.20	0.82	0.24	0.23	0.53	0.68
P-value[6]	<0.0001	<0.0001	0.0005	0.0439	0.0097	<0.0001	<0.0001	<0.0001	0.0008

Superscripts ([a-c]) indicate significant difference among means in the same column (P<0.05).
[1]Wet Residual Yolk Sac
[2]Dry Residual Yolk Sac
[3]Wet Yolk Free Body Mass
[4]Dry Yolk Free Body Mass
[5]Standard error of means belonging to the different treatments within the various hatch performance
[6] *P*-value of columnar means

Hatch performance of broiler chicks presented in Table 9 above. Chick weight recorded similar values with ages 39 and 41 this was followed up by age 31 the age 29 with age 28 being the least. The chick weight was significantly (P<0.01) different. It should be noted that management of breeders is important. Day old chick weight have been known to be proportional to the age of their parents especially between 25and 35 weeks and tends to stabilize after wards. So how farmers manage their feed and sexual maturity for the breeds could determine their uniformity of the chicks (Toudic, 2006). Significantly this current study agrees with that of Petek *et al.*(2010) in which significant difference was observed for the day – old body weight. Hatch weight in small group (length less than 18.0cm) was found to be significantly lower than the longer group (length greater than 18.3cm). Again, chick weight according El Sabry *et al.*(2013) was significantly influenced by the time chicks were hatched, where late hatch chicks showed heavier weight than chicks hatched on early hatch.

The chick length showed a similarity in ages 28, 29 and 31 with age 39 following then the least value recorded by age 41. Chick length was significantly (P<0.01) different due to a more uniform flock. Hill (2001) and Wolanski *et al*. (2006) agrees that length of the chick is likely to be much more important in obtaining uniformity of flock. Again the correlation coefficency in their experiment with other growth parameters and length are positively significantly (P<0.05). Agreeably, Decuypere and Bruggeman (2007) reported that in their research a strong correlation existed between chick length at hatch and other growth parameters which point to the fact that chick length could be used to show chick growth potential. According to Molenaar *et al.* (2008) not only should the female length be considered but also increase in the length of chicks in male broilers could impact positively on body weight especially those gotten from same egg size.

Shank length was significant at (P<0.01).Shank length recorded similar values with ages 41 and 39 followed by 29 and 31 with the least being age 28. This is due to strain of broiler used since shank length is used as a tool for the determination of fertility. This is in agreement with Yahaya et al. (2012) in their study made comparison between birds body conformations range between 0.977 and 0.795, all showing strong positive relationship between them. Concluded that there is a linear relationship between other body measurement including body weight and shank length for both Hubbard and Arbor Acre strains.

There was significance (P<0.05) with navel score. Similar values were recorded with ages 41 and 39 followed by 31, 29 and 28. Values of the navel score is due to the age of chick this is in line with Fasenko and O'Dea (2008) in their research indicated that the presence of leaky or button navel did not negatively affect body weights on day-old chick.

Intestine weight was significantly (P<0.01) with ages 41 and 31 recording similar values while ages 39, 29 and 28 follow with the least values. According to Scott and Silversides (2000) growth parameters (intestine weight) could be affected when the temperature for storing eggs is longer than more than six days. This suggests that temperature is a reason for the low significance in intestine development.

Both the dry and wet RYS were highly significantly (P<0.01) different. They showed corresponding similarity in ages 41,39, 31 followed by age 28 but there was a change with the values in age 29 for both the dry and wet RYS. This could be attributed to the availability of feed and water immediately after hatching the chick (Mukarami *et al.*, 1992). In another study agreeably, the cause for the unabsorbed yolk sac may have been due to inability for the lymphocyte to move during the conversion of the umbilical stalk to connect to the yolk sac to the cavity of the small intestine (Buhr *et al.,* 2006)

Wet and Dry YFBM indicated significance (P<0.01). Age 41 showed corresponding increases in Egg sizes which later determines the size of the day old could account for the significance of both the wet and dry YFBM. This is in line with Decuypere and Bruggeman (2007) assertion that body weight at day old was mutually related to egg size and not to development and performance parameters like YFBM because yolk sac may not have been absorbed totally.

Table 10: Percentage results of the different batches of hatched chicks in relation to parental age

Age/ Weeks	%intestine weight[1]	% wet RYS[2]	% Dry RYS[3]	% Wet YFBM[4]	%Dry YFBM[5]

28	3.72[a]	7.18[b]	4.93[b]	92.12	68.20
29	3.03[a]	8.64[b]	7.70[a]	88.41	64.71
31	3.67[a]	9.84[ab]	7.81[a]	88.71	65.85
39	3.03[a]	8.17[ab]	6.36[ab]	88.47	60.27
41	3.84[a]	10.03[a]	8.03[a]	88.64	65.30
SEM[6]	0.22	0.55	0.54	2.02	2.52
P-value[7]	0.0178	0.0016	0.0003	0.6438	0.2678

Superscripts ([a, b]) indicates significant difference among means in the same column ($P<0.05$).

[1]% Intestine weight = (Intestine weight /chick weight)*100

[2]%Wet Residual Yolk Sac= (Wet Residual Yolk Sac/chick weight)*100

[3]%Dry Residual Yolk Sac= (Dry Residual Yolk Sac/chick weight)*100

[4]%Wet Yolk Free Body Mass= (wet Yolk Free Body Mass/chick weight)*100

[5]%Dry Yolk Free Body Mass= (Dry Yolk Free Body Mass/chick weight)*100

[6]Standard error of means belonging to the different treatments within the various hatch performance

[7]*P*-value of columnar means

The percentage intestine weight has significantly similar values for all the ages. The percentage intestine weight was the least significantly ($P<0.05$) different. Temperature effect is very paramount to the development of organs during the embryo development (Lekrisompong,2005). According to Yalcin and Seigel (2003) changes in incubation temperature (36.9^{0}C and 39.6^{0}C) played an important role in organ development (Lekrisompong,2005).This means temperature tend to affect the conditions of the organs. In addition, Leksrisompong (2005) stipulate in her experiment intestine, proventriculus and gizzard of chicks incubated in high temperature were lower in size when there was an increase in temperature.

Percentage wet and percentage dry RYS were both significantly ($P<0.05$) different. RYS whether dry or wet is well absorbed when feed is made available to chicks in time. Mahmoud and Edens (2012) supports this when in their research broiler chicks were feed access was delayed .It was noticed that chicks from the older breeding hens imbibe more yolk within two days with no feed delayed effect. The time feed was introduced, chicks from the feed delayed group showed an enormous increase in the weight of the small intestine relative to body weight, a little more than ($P < 0{\cdot}05$) the control group across all the various ages of the breeder flock.

Both percentage wet and dry YFBM were not significantly ($P>0.05$) different among the different age groups. The main cause to its insignificance was due to dehydration of the chicks in the era of power fluctuation which could have affected temperature and humidity. According to Bruzual *et al.* (2000) the length of time that chicks are made to linger in the hatcher could affect the growth parameters and increase mortality rate. Additionally, Bruzual *et al.* (2000) stated that dehydration of chicks hatch is due to the relative humidity of the machine and how long it took for chicks to be removed from the hatcher. Wilson, (1991) stipulates that relative humidity and type of incubator could be a major cause for dehydration to occur.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

- There were eight hatcheries found but only seven were in operation.
- Most of the hatchery personnel lacked basic training
- Hatcheries were not adhering to optimal standards for temperature and humidity so this affected their chick weight, chick length, shank length, navel conditions, weight of intestines, YFBM and YS

5.2 Recommendation

- Research into specific breeds and their respective embryonic development conditions must be studied on the various incubation systems in respect to our climate is important to give farmers the right information needed for development.
- Hatcheries should be placed under one umbrella and monitored by the Animal Production Directorate of MoFA and Animal Research Institute, separate from the Ghana National Poultry Farmers Association and their activities monitored so that high quality chicks will be produced.
- There should be a legislative instrument to guide the opereations of hatcheries in Ghana to ensure the production of day of chicks.

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7.0 APPENDICES

QUESTIONNAIRE FOR THE HATCHERY SURVEY

COVER SHEET

Poultry farmers in Ghana have often complained about the availability of day-old chicks to ensure a sustainable meat and egg production to meet national needs. However, it is not clear how many hatcheries are in Ghana that operates on commercial/research basis to meet national demand. It will be important to develop statistics on the number of hatcheries, their capacity and utilization. This research seeks to conduct a survey to meet the above goals. The survey will also seek information on expert's information available in various hatcheries and how this could impact incubation outputs.

Could you kindly respond to the questions according to your own opinion and be realistic as much as possible.Thank you for your time and willingness to fill this questionnaire.

A. **Kindly tick [√] for the following set of questions**

1. Gender Male [ ] Female [ ]
2. Age 18-28[ ] 28-38[ ] 38-48[ ] 48-58[ ] Above 58[ ]
3. Religion Christian [ ] Muslim [ ] Traditional Worshiper [ ] Others [ ]
4. Education JHS [ ] SHS [ ] Diploma [ ] HND [ ] Degree [ ] Masters [ ] PHD [ ]

B. Kindly tick [√] -YES or NO where necessary and fill in for the rest of the questions below.

5. What is the name of your hatchery? ....
6. Do you have any other work apart from the hatchery work? ....
7. How old is hatchery (in years)? ………………………………………………………….
8. Is the hatchery part of a farm or it's a lone hatchery…………………………………........
9. What is your main reason for establishing the hatchery…………………………………..
10. What is the maximum capacity of hatch per incubation………………………………
11. What percentage of your incubator capacity do you utilize per month now……………...
12. How often do you incubate eggs…………………………………………………
13. What kind (type/brand) of incubator do you use? ....
14. What type of incubation system do you use? Multi-stage system [ ] Single-stage system [ ]
15. How many incubators do you have? How much multi- stage system? [ ] how many Single-stage system? [ ]
16. What is the egg capacity of each type? Multi-system[] single-stage system[]
17. Approximately, how many farms receive chicks from your hatchery?...
18. What is the price of each day old chick?..
19. What are some of the observations you make on your day old chicks that may be a problem………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
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………………………………………………………………………………………………
……………………………………………………………………………………………..
20. How many farms receive chicks your from your hatchery? ……………………………..
21. Do you follow up the farms which take day-old chicks from your farms? Yes [ ] No [ ]
22. How frequent?...
23. Do you perform any hatchery assessments for chick quality ?Yes [ ] No [ ]
24. Who performs these exercise for you………………………………………………….
25. How many hatchery workers do you have? …………………………………………….
26. How many are trained? ………………………………………………………………
27. Where did these this /these person(s)receive their training………………………………
28. How many are untrained……………………………………………………………
29. Do you have a hatchery manager? Yes [ ] No [ ]

30. Has he/she had any training in managing a hatchery? Yes [ ] No [ ]
31. Do you know the relative humidity you maintain in your incubator ?Yes [ ] No [ ]
32. If yes, can you specify……………………………………………………………
33. Do you know the relative humidity you maintain in your incubator? Yes [ ] No [ ]
34. If yes ,can you specify……………………………………………………………
35. Do you have an egg storage room? Yes [ ] No [ ]
36. What are the temperature and relative humidity………………………………………

PARENT STOCK

37. Do you maintain your parent stocks? Yes [ ] No [ ]
38. What type of parent stock do you have? layer[] broiler breeder or egg types broiler[]
39. What number (how many) of layer parent stock do you have…………………………
40. What number of broiler parent stock do you have…………………………………..
41. What type of breeds do you keep as your parent stock………………………………….
42. Do you carry out breeding program to maintain your own parent stock from existing old stock? Yes [ ] No [ ]
43. Do you make your own parent stock from existing old stock? Yes [ ] No [ ]
44. Do you import each generation? Yes[] No[]
45. Do you import eggs to hatch? Yes[] No[] (if No go to 47)
46. Do you have more unfertilized eggs than fertilized eggs in imported eggs? Yes [ ] No [ ]
47. What percentage are unfertilized…………………………………
48. Do you have more unfertilized eggs than fertilized eggs in the local eggs? Yes [ ] No [ ]
49. What percentage are unfertilized………………………………………………………..
50. Do you incubate eggs right after collection? Yes [ ] No [ ]
51. How long does the egg remain outside after collection? Yes [ ] No [ ]
52. Do you ensure that the eggs sitting in a hatcher at one time are uniform in size? Yes [ ] No [ ]
53. Do you receive hatching eggs from different sources Yes [ ] No [ ]
54. How long do you store your eggs before incubation ?Yes [ ] No [ ]
55. Do you consider that the thin tip of eggs should stay down ?Yes [ ] No [ ]
56. At what temperature are the eggs stored before being hatched ?Yes [ ] No [ ]
57. Do you know the genetic make- up of the flock ?Yes [ ] No [ ]
58. Do you concentrate on fertility in males and not females? Yes [ ] No [ ] both[ ]
59. How do you handle possible exploders…………………………………………………
60. Do you pre-store eggs before incubation ?Yes [ ] No [ ]
61. Do you pre-heat eggs prior to onset of incubation for uniform temperature Yes [ ] No [ ]
62. Are you aware that the age of flock play important role in chick quality Yes [ ] No [ ]
63. Any if there is that you can share on this

matter?...
....
....
....
....

64. Do you pay attention to the external parameters stated below. Tick **(√)**Yes or No

PARAMETERS	
Egg shape	Yes [ ] No [ ]
Egg shell	Yes [ ] No [ ]
Egg size	Yes [ ] No [ ]

65. Do you pay attention to the internal parameter occasionally stated below? Tick **(√)**Yes or No

PARAMETERS	
Albumen	Yes [ ] No [ ]
Yolk	Yes [ ] No [ ]
Embryo	Yes [ ] No [ ]

66. Do you raise broilers from your hatchery? Yes [ ] No [ ]
67. Is it more challenging hatching broilers than layers ?Yes[]No[]
68. Do you have any meat processing operation/market for chicks hatched? Yes [ ] No [ ]
69. Do you think the government is doing enough to help hatcheries function in this country? Yes [ ] No [ ]
70. What do you think the Government can do to help……………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
71. Are you a member of any poultry production related association? Yes [ ] No [ ]
72. What is the name of the association……………………………..................................
73. Do you think the association is doing enough to improve the poultry industry in your region? Yes [ ] No [ ]
74. Are NGOs involved in poultry development in your area? Yes [ ] No [ ]
75. What exactly do they do on poultry development………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
76. Did the manufacturer of your incubator give you any training on its operation? Yes [ ] No [ ]

77. Do you take records on the number of day old chicks that your hatchery produces every year? Yes [ ] No [ ]
78. Do you think your hatchery workers need training? Yes [ ] No [ ]
79. Do you easily get services of a competent veterinarian services promptly? Yes [ ] No [ ]
80. When your chick die what reasons are given by the veterinarian……
81. How do you package your day-old chick for delivery ……
82. How many chicks go into one container…………………………………………………..
83. What is the average weight of the container after stocking………..
84. Are the containers labeled (if any)? Yes [ ] No [ ]
85. What do you label on the container……
86. Does biosecurity or hatchery hygiene play a major role in good hatchery management? Yes [ ] No [ ] (If No proceed to question **Table D**).

C. If Yes, answer the biosecurity or hatchery hygiene questions in the table below by ticking (√)the appropriate one

	I strongly disagree	I disagree	neutral	I agree	I strongly agree
Is the hygiene on the breeder farm a starting point of a hygienic hatchery					
Eggs can be infected through the pores, hairline cracks and infected breeders					
Eggs can be at risk with through vectors such as hands trays ,transport equipment					

Washing hands with soap or alcohol based liquid before handling eggs prevents infection.					
Disinfect hatchery baskets and chick boxes immediately after washing by spraying					
The dip system used at the entrance enough to disinfect effectively					

D. Respond to the following statements on the efforts made by the Government to strengthen poultry production by ticking (√) the appropriate one

	I strongly disagree	I disagree	neutral	I agree	I strongly agree
The formulating policies and regulations are NOT enough for high production					
Removal of customs duties on poultry inputs(feed, feed-additives, drugs and vaccines) are NOT enough					
Facilitating improved access to veterinary services is important					

Poultry import duty should be increased with additional VAT and additional charges					
MOFAs engagement with Poultry association and stakeholders to mitigate impact of import poultry products on locally produced poultry products is NOT enough					
The Governments trade policy to reform the administration of the import permit system in order to enhance its monitoring is a step in the right direction.					
Establishment of the poultry council to regulate the activities of operators in the industry is a step which would encourage competition.					
Farmers have benefited from Export Development and Investment Fund which is supposed to give loans the them.					
Educational institution should be empowered to do more research to improve the poultry industry					

Finally if there is anything you would like us to take note it can be written below…………………………………………………………………………………………
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……………………………………………………………………………………………………
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……………………………………………………………………………………………………

Thank you very much taking time off your busy schedule to help in the promotion of poultry production in Ghana and the need to help in this research.