THE EVALUATION OF LAYING PERFORMANCE, EGG QUALITY, FERTILITY, HATCHABILITY, AND CHICK QUALITY OF SA51A AND SA31L BROILER BREEDERS IN GHANA

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ABSTRACT
This research evaluated the laying performance, egg quality, fertility, hatchability, and chick quality of SA51A and SA31L broiler breeders in Ghana. A total of 2500 breeders from each strain were examined from 20 to 60 weeks of age. Each strain was randomly replicated five times with 500 birds in each replicate. Each strain was crossed with Sasso Rainbow X with the male-to female ratio of 1:10. The experimental birds were kept in 10 open-sided deep litter pens. The experimental design used was completely randomized design. The parameters measured were; feed intake, feed conversion ratio, hen-day egg production, hen-housed egg production, egg weight, egg mass, laying mortality, egg quality, fertility, hatchability, saleable chicks, and chick quality. Eggs were collected twice daily for 10 months. One hundred (100) eggs from each strain were sent to the Department of Animal Science, KNUST for internal and external egg quality analysis. A total of 900 fertile eggs were sampled for setting, 450 from each strain. Before setting for incubation, eggs were weighed, labeled, and assigned into 5 replications of 90 eggs per strain. After 18 days of incubation, eggs were candled for live embryos. After the hatch was pulled, the chicks were visually observed. Chicks that were clean with dried feathers, bright and clear eyes, sealed navels, and without deformities were grouped as saleable chicks and those without these qualities were grouped as non-saleable chicks. Individual chick weights of samples from each strain were measured using Pro Scout electronic balance. Chick length and shank length were measured using a 30 cm ruler. The results show that under the conditions of this experiment; the performance of SA51A was not significantly different (p>0.05) from SA31L in terms of the number of eggs laid, hen-day egg production, hen-house egg production and internal egg qualities measured. However, SA51A strain had a higher performance than the SA31L strain (p<0.05) in terms of egg weight, fertility, hatchability, chick weights and saleable chicks. The onset of egg production was 20 weeks for both strains, the egg production peaked above 80% from week 28 for both strains up to week 48 before it began to decline. SA51A recorded the highest egg production at week 30 while SA31L had its highest at week 31. We concluded that SA31L and SA51A females crossed with Sasso Rainbow X males can be used as broiler breeders for chicken meat production to increase productivity and economic returns.

Keywords: strains, fertility, hatchability, genetic, breeding

INTRODUCTION

The poultry business is increasing and becoming more industrialized in many parts of the world. The rise in the population, increased purchasing power, and urbanization have been major growth engines for the industry. To meet this rising demand for meat, the broiler industry accounted for over 39% of global meat production in 2019 (FAO, 2020).

The availability of day-old chicks is critical to the success of the poultry production chain. The breeding industry's purpose is to produce healthy chicks capable of expressing their full genetic potential (Willemsen *et al*., 2008). Hatcheries must deliver not just excellent hatchability, especially with a limited hatch window, but also high-quality day-old chicks to broiler farmers. Broiler farmers seek chicks with strong development potential, which will result in a large slaughter output at the close of the rearing period (Mukhtar *et al*., 2013).

Each breeder strives to provide favourable conditions and a breeding system in which parents' reproductive characteristics enable the production of more fertilized eggs of good quality, quality chicks at a lower cost, but with a good foundation for their successful breeding and favourable production performances (Narushin and Romanov, 2002). A one-unit improvement in the hatchability of total eggs, a major indicator of production in breeder farms, translates into a significant financial gain over time (Ipek and Şahan, 2004). To achieve the best incubation results, the incubation settings must be modified to fit the needs of the embryo (Meijerhof, 2009). It is well-recognized that the embryonic environment influences embryonic growth in many animals (Leksrisompong *et al*., 2007).

There are different ideas about how to describe chick quality, according to Tona *et al*. (2005), but in general, a good-quality chick is one with high-performance potential. This includes external as well as internal variables. A good quality chick has developed optimally during incubation without evidence of any physical abnormality. Chicks of good quality have high performance in terms of daily growth which leads to more breast meat in broilers and high egg production in layers (Molenaar *et al*., 2008). The economic performance of a flock is immeasurably more when the chicks are of good quality. This enables productivity in both broilers and layers (Houghton, 2011).

Many factors contribute to the efficient production of day-old chicks, including good breeding animal selection and management, post-lay treatment of viable eggs and optimal incubation procedure (King'Ori, 2011). For embryos to grow successfully, the conditions required are adequate temperature, 50 to 55% humidity level, suitable gas exchange, and regular egg turning (COBB Hatchery Management Guide, 2008). Tona *et al*. (2003) also reported that several factors influence chick quality and subsequent growth performance, either directly or indirectly. Egg storage period, breeder age, and breeder line all have an impact on embryonic development and day-old chick features. Egg weight is one of the most important parameters influencing the subsequent productivity of layer and broiler chickens (Sklan *et al*., 2003).

Sasso chickens are very adaptive to the tropical environment, multi-colored, sturdy, and easy-to-manage birds that may be raised in a variety of production systems (Mengistie *et al*., 2019). Sasso hens are a relatively new addition to Africa's tropical environment. Apart from preliminary data on their physical characteristics (Yakubu *et al*., 2018), there are no additional productive records on these birds in Ghana. The importance of introducing tropically adapted genotypes with good performance to resource-strapped chicken farmers has been underlined.

Therefore, this research aimed to examine the laying performance, some egg quality traits, hatchability traits, and chick quality of two Sassso broiler breeders in Ghana so that hatcheries could choose the strains with the better performance to increase productivity and economic returns.

MATERIALS AND METHODS

Experimental Design and Study Location

The study was conducted at the Breeder Farm of the West Africa Agriculture Farms Limited at Ofoase Kokoben and the Department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi – Ghana from October, 2021 to July, 2022.

A total of 5000 female Sasso broiler breeders were studied from the onset of lay for 10 months. They comprise 2500 SA51A and 2500 SA31L female broiler breeders. Each strain was replicated five times with 500 birds in each replicate using a completely randomized design. Both strains were crossed by Sasso Rainbow X with the ratio of 1:10.

The experimental birds were kept in 10 open-sided deep litter pens. The birds were reared and fed according to the Sasso breeder management guide (2022). Standard procedures concerning preventive vaccination and medication were employed during the study period. Water was provided *ad libitum*

The parameters measured throughout the study period were; feed intake, hen-day egg production, hen-housed egg production, egg weight, egg mass, laying mortality, egg quality, fertility, hatchability, saleable chicks, and chick quality.

Feeding of Experimental Birds

All birds were fed a similar diet containing 17.5% crude protein and 2700 kcal/kg metabolizable energy. Feed consumption per hen per day from age 20 weeks to 60 weeks was 125 g.

Egg Production traits

Age at onset of lay, age at which egg production was above 80% and age at which egg production began to decline were observed. Eggs were collected twice daily for 10 months. Hen-day egg production was determined by finding the percentage of the total number of eggs produced on a day to the total number of hens present on that day. Hen-house egg production was also calculated by finding the percentage of the total number of eggs laid on a day to the total number of hens housed at the beginning of the laying period.

Egg Quality Characteristics

Two hundred (200) eggs collected from each strain were sent to the Department of Animal Science, KNUST for internal and external egg quality analysis. The eggs were weighed individually using Pro Scout Electronic Balance. After that, the egg height and egg width were measured using vernier calipers. The eggs were then broken and albumen height was measured by Tripod Spherometer, albumen weight, and yolk weight were measured using Pro Scout Electronic Balance, and yolk colour was measured by DSM Yolk Colour Fan. The shells of broken eggs were dried at room temperature before shell weight was recorded. Shell thickness was measured using a micrometer screw gauge.

Incubation, candling and hatching

After the egg collection, eggs with cracks, deformities and dirt stains were sorted out. A total of 900 fertile eggs were sampled from the eggs collected for setting thus 450 eggs from SA31L and 450 from SA51A at age 36 weeks. Before setting for incubation, eggs were weighed, labeled, and assigned into 5 replications of 90 eggs each/strain. The eggs were incubated for 21 days at 37.5^{o}C and 30-40% relative humidity and turned each hour through an angle of 90°.

Candling was done on day 18 of incubation, eggs with evidence of living embryos were transferred from turning trays to hatching baskets and sent to the hatching room. Eggs that looked clear were recorded as infertile eggs and eggs with evidence of dead embryo were broken and recorded as early embryo mortality. On the 21st day, the hatch was pulled and the number of hatched chicks per treatment or strain were counted. Unhatched eggs were broken to determine late embryonic mortality. Fertility was determined by finding the percentage of fertile eggs to the total number of eggs set. Hatchability was determined by calculating the percentage of the eggs that hatched to the total number of fertile eggs set.

Measurement of Chick Quality

After the hatch was pulled, the chicks were visually observed. Chicks that were clean with dried feathers, bright and clear eyes, sealed navels, and without deformities were grouped as saleable chicks and those without these qualities were grouped as non-saleable chicks.

Individual chick weights of samples from each strain at day-old were measured using Pro Scout electronic balance. The chick length was measured by placing the tip of the beak at the zero mark of the ruler and stretching the chick along the ruler to the end of its middle toe. The chick shank length was measured from the hock joint to the metatarsal pad using a 30 cm ruler.

Statistical Analysis

Data collected were analyzed using the General Linear Model procedure of the Statistix software version 8.0 at 5% level of significance. The statistical model used was defined as shown below:

$$Y_{ij} = \mu + S_i + \varepsilon_{ij}$$

Where:

Y_{ij} = Response recorded on the measured parameters

μ = The population mean

S_i = Main effect of strain

ε_{ij} = Residual error term

Differences between means were separated using Tukey's studentized range test.

RESULTS AND DISCUSSION

External Egg Quality of Sasso Eggs as Influenced by Strain

There were significant differences ($p<0.05$) between the two strains regarding egg weight, egg width, shell thickness, and shape index (Table 1). Egg weight is one of the most essential metrics for both consumers and egg farmers (Genchev, 2012). SA51A recorded significantly heavier ($p<0.05$) egg weights, egg width, and egg shape index than SA31L. The findings of this experiment were in agreement with the results of Hanusova *et al.* (2015) who observed significant differences in egg weight and egg length between Oravka and Rhode Island Red laying hens. They concluded that egg weight is affected by breed, genetic variables, laying hen age, season, climatic circumstances, nutrition and laying hens' uniqueness.

SA31L recorded significantly thicker shells than SA51A ($p<0.05$). Similar reports were made by Silversides *et al.* (2006) who reported that eggshell thickness quality is genetically determined, and egg quality features fluctuate amongst hen strains. The significant difference observed in shape index in the current study is in agreement with the findings of Shaker *et al.* (2017) who attributed the differences observed in shape index to the differences in genotypes. The results obtained on eggshell thickness in this study can be attributed to different strains used for the study.

Internal egg characteristics of Sasso eggs as influenced by strains

The influence of strains on the internal egg qualities of Sasso breeder eggs are presented in Table 1. There were no significant differences ($p>0.05$) between the two strains in relation to albumin weight, yolk weight and yolk colour. A similar

Table 1: External and internal egg qualities as influenced by broiler breeder strains

Source	Egg Weight (g)	Egg Length (cm)	Egg Width (cm)	Shell Thickness (mm)	Albumin weight (g)	Yolk Weight (g)	Yolk Colour	Shape index (%)
SA31L	59.59^b	5.87	4.47^b	0.36^a	38.42	15.26	3.20	76.15^b
SA51A	60.63^a	5.87	4.53^a	0.35^b	38.65	15.47	3.20	77.27^a
SEM	0.1595	0.0357	0.0235	0.002049	0.1243	0.1078	0.0548	0.2268
p-values	0.0001	0.8281	0.0227	0.0020	0.0942	0.0925	1.0000	0.0011

[a-b] *Different letters indicate significant differences between means in the same column ($p<0.05$), SEM: Standard Error of means*

observation was made by Rajkumar *et al*. (2009) who reported no significant differences in internal egg characteristics among different genotypes. The non-significant differences observed among the internal qualities studied could partially be attributed to the fact that the birds were fed with the same diets and the eggs being subjected to the same storage conditions.

Percentage fertility and hatchability as influenced by strains

The results of percentage fertility, hatchability and embryo mortality patterns as influenced by strains are presented in Table 2. Percentage fertility and hatchability were significantly ($p < 0.05$) affected by strain. SA51A recorded higher fertility and hatchability compared to the SA31L. The findings of this study are in agreement with those of Boluwatife (2022) who stated that genotype affects fertility and hatchability and recommended that the genotype with the greatest fertility and hatchability percent should be used for breeding, while other genotypes should be improved. A similar report was made by Yassin *et al*. (2008) who stated that hatchability is impacted not only by hatchery management features but also by strain. The significant differences observed in this study could be attributed to the differences in the genetic makeup of both strains used.

There were no significant differences ($p > 0.05$) between the two strains concerning early and late embryo mortalities. It is usual practice at a hatchery to keep hatching eggs for several days. The survival of an embryo may be thought of as a function of its genetic makeup, which is determined by genes inherited from the sire and dam, and the egg environment, which is determined exclusively by the dam (Wolc *et al*., 2009). Early embryonic death can be related to chromosomal abnormalities and lethal genes, implying that embryo survival depends on both parents (Liptói and Hidas, 2006).

According to Hamidu *et al*. (2018), storing eggs in a cold room influenced the quality attributes of eggs positively; however, room temperature had a detrimental impact on several egg quality characteristics by reducing egg weight, altering the blastoderm, and decreasing yolk index and albumen height during egg storage.

The embryo mortalities in this study could be attributed to the prolonged storage (3 days) in the cold room before incubation. This cannot be assigned to the genotype of the birds because the two strains were not different in embryo mortalities for this particular study.

Chick quality characteristics as influenced by broiler breeder strains

The results of chick weight, chick length, shank length and chick yield as influenced by strains are presented in Table 3. There were no significant differences ($p > 0.05$) between the two strains in relation to chick length, shank length and chick yield. However, chick weight was significantly ($p < 0.05$) influenced by the strains. SA51A recorded a higher (40.20g) chick weight than SA31L (38.84g). The sizes of eggs influence the size of the chicks hatched. Chick weight is 66-68% of the egg mass therefore, day-old chicks from eggs around 60_g shall averagely

Table 2: Percentage fertility and hatchability as influenced by broiler breeder strain

Source	Number of Egg Set	Fertility (%)	Early Embryo mortality (%)	Late Embryo Mortality (%)	Hatchability (%)	Saleable chicks (%)	Non-saleable chicks (%)
SA31L	450	86.89[b]	13.46	11.04	75.49[b]	97.95	2.05
SA51A	450	92.89[a]	10.96	9.29	79.76[a]	98.48	1.52
SEM		2.485	1.40	1.40	1.004	1.21	1.21
p-values		0.042	0.111	0.243	0.003	0.675	0.67

[a-b] *Different letters indicate significant difference between means in the same column (p<0.05), SEM: Standard Error of means.*

have a mass of 40 g with specific chick masses of 34 to 46g. Water loss during incubation accounts for the reduction in egg weights and variation in chick weights from eggs of the same size. The final chick weight is affected by the period of the stretch from incubation, removal from the hatcher and conveyance. The time spent in the hatcher has more effect than the time in the chick room or delivery vehicle which has a lower temperature (NewCOBB Hatchery Management Guide, 2008).

The higher chick weights produced by SA51A could therefore be attributed to the higher egg weights and shape index, and differences in genetic make-up of the birds.

The findings of this study were in agreement with Fathi *et al*. (2022) who recorded the highest chick weights in genotypes with higher egg weights. Fathi *et al*. (2022) concluded that the settable egg weight and genotypes are the most important factors influencing the relative weight of hatched chicks. It is known that a positive correlation exists between chick weight and egg weight in broiler chickens because bigger eggs contained more nutrients than smaller eggs, and so growing embryos from heavier eggs tended to have more nutrients for their growth and development (Iqbal *et al*., 2017).

Egg production performance as influenced by strain and age

The results of egg production performance as influenced by strains and age are presented in Figure 1 and Table 4.

There were no significant differences ($p > 0.05$) between the two strain in terms of the number of eggs laid, hen-day egg production, and hen-house egg production. The findings of this current study disagree with Sharma *et al*. (2022) who found significant differences in HDEP when different strains were used

The pattern of egg production curves is determined by sexual maturity, followed by a stage of rising output to a maximum or production peak, followed by a continuous reduction in egg production or persistence of production (Wolc *et al.,* 2011). The egg production curves of the experimental hens followed the standard egg production curve for a flock, which peaks during the first 8 or 9 weeks of production and falls until the conclusion of the production period (Grossman and Koops, 2001).

In the present study, the age at onset of egg production was 20 weeks for both strains. SA31L reached 50% of egg production at week 26 whereas SA51A reached 50% egg production at week 25. In this study, the highest hen-day egg production (peak) was observed at week 31 for SA31L and week 30 for SA51A.

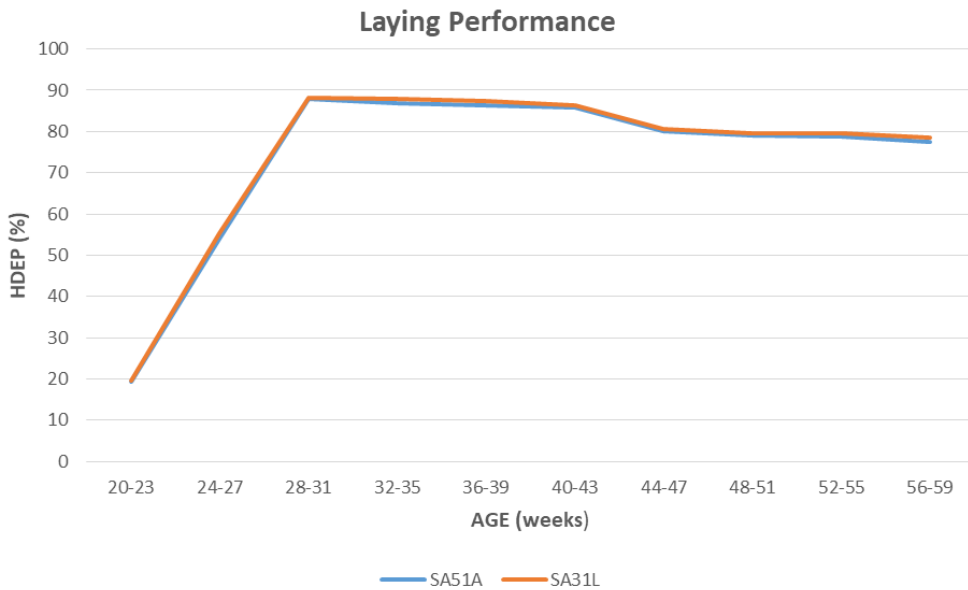
The hen-day egg production peaked above 80% from week 28 to week 48 before it began to decline for both strains. Feed consumption (quality and quantity), water intake, intensity and length of light received, parasite infestation, illness, and a variety of management and environmental conditions can all have an impact on egg production (Jacob *et al*., 2000).

In the present study, the age at onset of egg production was 20 weeks for both strains. SA31L reached 50% of egg production at week 26

Table 3: Chick quality as influenced by broiler breeder strain

Source	Chick Weight (g)	Chick Length (cm)	Shank Length (cm)	Chick Yield (%)
SA31L	38.84^{b}	16.92	2.36	65.19
SA51A	40.20^{a}	17.02	2.33	66.27
SEM	0.576	0.066	10.67	0.99
p – values	0.046	0.18	0.243	0.313

[a-b] *Different letters indicate significant difference between means in the same column (p<0.05), SEM: Standard Error of means.*



p-value = 0.2949

Figure 1: Influence of broiler breeder strains SA51A and SA31L on laying performance (HDEP)

Table 4: Influence of broiler breeder strains SA51A and SA31L on laying performance (HDEP) and HHEP

Age (weeks)	HDEP (%)		HHEP (%)	
	SA31L	SA51A	SA31L	SA51A
20-23	19.34	19.47	19.34	19.47
24-27	54.06	55.41	53.90	55.21
28-31	87.32	88.11	86.74	87.52
32-35	86.80	87.85	85.88	86.91
36-39	86.42	87.32	85.10	85.91
40-43	85.91	86.46	84.21	84.80
44-47	80.20	80.67	78.22	78.87
48-51	79.03	79.63	76.74	77.53
52-55	78.88	79.47	76.25	77.17
56-59	77.54	78.52	74.67	76.00
Mean	73.55	74.29	72.10	72.94
SE	0.6618		0.2694	

whereas SA51A reached 50% egg production at week 25. In this study, the highest hen-day egg production (peak) was observed at week 31 for SA31L and week 30 for SA51A. The hen-day egg production peaked above 80% from week 28 to week 48 before it began to decline for both strains. Feed consumption (quality and quantity), water intake, intensity and length of light received, parasite infestation, illness, and a variety of management and environmental conditions can all have an impact on egg production (Jacob *et al*., 2000).

Pre-laying and Laying Mortalities as influenced by strains

The results of pre-laying mortalities and laying mortalities as influenced by strain are presented in Table 5. There were no significant differences ($p > 0.05$) between the two strains in terms of the pre-laying mortalities and laying mortalities.

In the production of animals, mortality is frequently employed as a substitute for health and welfare monitoring. From the beginning of lay to the time of slaughter or flock culling, mortality in laying hens is often reported as cumulative mortality over the course of the production period. According to research conducted around the world, free-range systems have the greatest death rates for layers, ranging from 5% to 12%. (Blokhuis *et al*., 2007).

The results of this study agree with the findings of Value (2020), who stated that Sasso hens are resilient breeds that can withstand severe outdoor conditions and may be reared using several management approaches ranging from free-range to intensive. The Sasso chicken has a strong immune system and is resistant to many avian infectious diseases (Garden, 2020). The low mortalities recorded can be attributed to the strong immune system of the Sasso hens.

Table 5: Pre-laying and laying mortalities as influenced by strains

Source	Pre-laying mortality (%)	Laying mortality (%)
SA31L	6.68	3.82
SA51A	6.00	3.62
SEM	1.0670	0.4124
p–values	0.0626	0.5417

[a -b] *Significant differences between means in the same column ($p<0.05$), SEM: Standard Error of means.*

CONCLUSION

It was concluded that under the conditions of this experiment, SA51A compared favourably with SA31L in terms of the number of eggs laid, hen-day egg production and hen-house egg production; but SA51A strain was superior to the SA31L strain in terms of egg weight, fertility, hatchability, chick weight and saleable chicks. The onset of egg production was 20 weeks for both strains whilst the egg production peaked above 80% from week 28 for both strains up to week 48 before it began to decline. The highest egg-lay for SA51A was at week 30 while that of SA31L was at week 31. The study recommends the use of commercial broilers produced by SA51A females crossed with Sasso Rainbow X males for chicken meat production to increase productivity.

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