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Evaluation of the performances of two artisanal incubators on the hatching of broiler breeding eggs (Yamoussoukro, Ivory Coast)

SORONIKPHOHO SORO [1,*], BOSSON NICOLAS ABOLY [1], NAHOULE SILUE [1], HAROUNA MORIBA KOFFI [1], KOFFI DONGO KOUASSI [2] and GBOKO KONAN GATIEN BROU [1]

[1] Peleforo Gon Coulibaly University, Department of Animal Science, Laboratory of Biology and Animal Health, Agropastoral Management Institute, Peleforo Gon Coulibaly University, Korhogo, Ivory Coast, Bp 1328 Korhogo.
[2] Peleforo Gon Coulibaly University, Department of Biological Science, Peleforo Gon Coulibaly University, Korhogo, Ivory Coast, Bp 1328 Korhogo.

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Abstract

To improve poultry production in Ivory Coast, a study was carried out in the commune of Yamoussoukro with 481 eggs from two breeds of meat breeders (Rouge Flesh and Kuroilers) which were collected during their reproduction. These eggs were distributed between three incubators, two of which were artisanal (Incubator 1 and Incubator 2) and one was industrially manufactured (Incubator 3), after determining their characteristics (weight, length and diameter). Incubation parameters were measured twice a day (at 8 a.m. and 5 p.m.) and brooding parameters such as apparent hatching rate, actual hatching rate, mortality rate embryonic and shell mortality rate were estimated. The results showed a significant difference ($p<0.05$) in the average weight of Rufous Flesh eggs (51.54±5.3 g) compared to Kuroiler eggs (50.02±5.54 g). The average temperatures recorded (37.40±0.55 °C for incubator 1; 37.58±0.49 °C for incubator 2 and 37.59±0.53 °C for incubator 3) were significantly identical ($p>0.05$). As for the hygrometry, that of incubator 3 (59.98±6.02 %) was significantly higher ($p<0.05$) than that of incubator 1 (54.58±1.80 %) and from incubator 2 (54.86±3.26 %). The actual hatching rate of incubator 1 (85.76±14.21 %) was significantly higher ($p<0.05$) than that of incubator 2 (70.85±14.48 %) and identical ($p>0.05$) to that of incubator 3 (73.95±16.45 %). Concerning the shell mortality rate, incubator 1 (1.03±2.18 %) recorded a significantly lower rate ($p<0.05$) than that of incubator 3 (7.43±4.56 %) and significantly identical ($p>0.05$) to that of incubator 2 (2.52±6.35 %). From this study, the artisanal incubators 1 and 2 meet the criteria for brooding and deserve to be used.

Keywords: Incubator; Eggs; Brooding parameters; Chicken; Yamoussoukro

1. Introduction

Ivorian poultry farming is divided between two main breeding methods (family mode and modern mode). The family mode uses local breeds and present throughout the territory but is mainly concentrated in the northern strip and the center of the country. Then the modern mode which uses selected strains and is mainly concentrated around urban areas and mainly around Abidjan (MIRAH, 2017).

In recent years, the modern poultry industry has experienced significant growth. We note a consumption of chicken meat which increased from 1.47 kg/inhabitant/year in 2012 to 2.62 kg/inhabitant/year in 2019, an increase of 78.23 % and 34 eggs/inhabitant /year in 2012 to 45 eggs/inhabitant/year in 2019, an increase of 32.3 %. The sector exceeded by 31 % the consumption objective initially set for chicken meat estimated at 2 kg in 2021. While for eggs, it only

* Corresponding author: SORO SORONIKPHOHO

obtained an 80% rate of progress towards achieving the targeted objective of 56 eggs/inhabitant/year in 2021 (MIRAH, 2022).

Despite these efforts, the poultry sector in Côte d'Ivoire only partially covers the national need for chicks. To make up for this deficit, the Ivorian State has increased and encouraged initiatives to improve poultry farming practices. However, mastery of the technical management of chick production remains one of the major constraints for breeders. According to Bamba (2019), various constraints still hinder the smooth running of the Ivorian poultry industry, namely the insufficient quality of feed and day-old chicks but also the distance of production centers from distribution areas. In addition, imported incubators are still not adapted to our local conditions, yet the demand for day-old chicks is constantly increasing. We are then witnessing a proliferation of clandestine hatcheries and certain breeders, with a view to expanding their breeding, are embarking on the production of chicks, often with artisanal incubators. How to curb the shortage of day-old chicks in Ivory Coast? Would manufacturing incubators locally be the best option? This work aims to explore the quality of two home-made incubators on egg hatching.

2. Materials et Methods

2.1. Biological material

The eggs used for the study came from two types of flesh breeders (Kuroiler breed and Red Flesh) from the Ange farm. A total of 504 eggs were collected, of which 481 eggs were incubated.

2.2. Technical equipment

The technical equipment used consisted of a Kitchen Scale SF400 electronic scale with a maximum capacity of 10 kg and a precision of 1 g used to weigh eggs, a flashlight and a telephone. for candling eggs, an electronic caliper from the Digital Caliper brand with a precision of 0.2 mm and a range of 150 mm used to measure the size of the eggs, an HTC 1 brand digital thermometer-hygrometer with an accuracy in terms of temperature and humidity of 1 °C and 5 % respectively for the measurement of temperature and humidity.

It was also made up of three incubators, two of which were artisanal, and one was industrial.

2.3. Methods

2.3.1. Collection, storage and transport of eggs

Eggs were collected twice daily, at 7 a.m. and 2 p.m., from each breeder batch. After collection, malformed eggs and those with broken shells were removed from the batches. Those showing no defects were identified, weighed and then the length and diameter were measured. They were then stored in the same building as the breeders in a fence to protect them against predators. Every four days, early in the morning, the collected eggs were transported from the farm to the hatchery where the condition of the eggs was checked to remove any with cracks.

2.3.2. Constitution of batches of eggs to be incubated and egg candling

According to weight, eggs were divided into three categories (small, medium and large). All eggs with a mass between 35 and 45 g were considered small, medium those with a mass between 46 and 55 g and large those with a mass between 56 and 65 g. The eggs of the two breeder strains (Kuroilers and Red Flesh) were equally distributed among the incubators. Incubations were performed in the mornings to facilitate daily data collection. During incubation, every morning and evening the temperature and humidity of each incubator were recorded. On the 18th day of incubation of each batch, with a telephone torch, a single candling was done to remove infertile eggs (figure 3) and those with dead embryos. After candling, only fertile eggs (figure 4) were placed in the hatcher.

2.3.3. Estimation of hatching parameters

The different hatching parameters (clear egg rate, fertility rate, embryonic mortality rate, intra-shell mortality rate of chicks, apparent hatching rate and the actual hatching rate) were calculated according to the proposed formulas. by Sanou (2005).

- **Clear egg rate** = [number of clear eggs / total number of eggs incubated] x 100.
- **Fertility rate** = [Number of fertile eggs / Number of eggs incubated] x 100.
- **Embryonic mortality rate** = [Number of eggs with dead embryos / Number of fertile eggs] x 100.

- **Apparent hatching rate** = [Number of chicks hatched / Total number of eggs incubated] x 100.
- **In-shell chick mortality rate** = [Number of chicks dead in shell / Number of fertile eggs] x 100.
- **Actual hatching rate** = [Number of chicks hatched / Number of fertile eggs] x 100

2.3.4. Statistical analyzes

Excel software was used not only to enter data during the study but also to draw graphs. Statistical analysis was carried out using Statistica 7.1 software. and the Student's t test made it possible to compare the means two by two at the threshold of 0.05.

3. Results

3.1. Determination of the characteristics of eggs to be incubated

Table 1 presents the results relating to egg characteristics. Red Flesh eggs were significantly (p<0.05) heavier (51.54±5.3 g) and larger (39.50±2.91 mm than Kuroiler eggs (50.02±5 .54 g for weight and 38.86±2.97 mm for diameter). On the other hand, the length of the eggs did not present a significant difference (p>0.05) with an average length of 51.84±4.05 mm for the eggs of Red Flesh and 52.06±4.03 mm for Kuroilers eggs. Table 2 shows the result of categorizing eggs based on chicken strain. There was no significant difference (p>0.05) between the number of eggs of the different categories depending on the strain.

Table 1 Physical characteristics of Red Flesh and Kuroiler eggs

Egg Characteristics	Red flesh	Kuroiler
Weight (g)	51,54±5,3 a	50,02±5,54 b
Length (mm)	51,84±4,05 a	52,06±4,03 a
Diameter (mm)	39,50±2,91 a	38,86±2,97 b

Nb: Values bearing the same letter on the same line are not significantly different (P>0.05)

Table 2 Number of Red Flesh and Kuroiler eggs per category

Egg categories	Red flesh	Kuroiler	P
Little	10,33±10,61b	16,00±15,77b	0,48
Medium	50,00±49,34b	54,00±53,28b	0,89
Fat	16,33±16,45b	14,33±14,78b	0,82

Nb: Values bearing the same letter on the same line are not significantly different (P>0.05)

3.2. Incubation parameters in incubators

Table 3 presents the average temperature and humidity of the three incubators. For temperature, incubator 1 recorded an average of 37.40±0.55 °C, incubator 2 an average of 37.58±0.49 °C and incubator 3 an average of 37.59±0. 53 °C. The temperatures of these three incubators are significantly similar (p>0.05). As for hygrometry, no significant difference was observed between incubator 1 (54.58±1.80 %) and incubator 2 (54.86±3.26 %). On the other hand, the hygrometry of incubator 3 (59.98±6.02 %) is significantly higher (p<0.00001) than those of the first two incubators.

Table 3 Comparison of average temperature and humidity of incubators

Incubators	Temperature (°C)	Hygrometry (%)
Incubator 1	37,40±0,55a	54,58±1,80a
Incubator 2	37,58±0,49a	54,86±3,26a
Incubator 3	37,59±0,53a	59,98±6,02b

NB : Values with the same letter in the same column are not significantly different (p>0.05).

3.3. Determination of brooding performance

3.3.1. Egg hatching performance depending on the incubators

Table 4 presents the hatching performances depending on the incubators. The actual hatching rate of incubator 1 (85.76±14.21 %) was significantly higher than that of incubator 2 (70.85±14.48 %). On the other hand, no significant difference was observed between the Actual hatching rate of incubator 3 (73.95±16.45 %) and that of the other incubators (incubator 1 and 2). Concerning the shell mortality rate, a significant difference was observed between incubator 1 (1.03±2.18 %) and incubator 3 (7.43±4.56 %), the *S*hell mortality rate of the incubator 3 (7.43±4.56 %) being significantly higher than that of incubator 1 (1.03±2.18 %). Regarding clear egg rate, embryonic mortality rate, fertility rate and apparent hatch rate, no significant differences were found between the three incubators.

Table 4 Hatching performance of the three incubators

Inc	**Clear egg rate**	**Embryonic mortality rate**	**Fertility rate**	**Apparent hatch rate**	**Actual hatching rate**	**Shell mortality rate**
1	10,92±8,14**b**	13,20±13,40**a**	89,07±8,14**a**	76,95±17,16**b**	85,76±14,21**a**	1,03±2,18**a**
2	5,28±5,59**b**	20,34±12,30**a**	94,72±5,59**a**	67,11±14,36**b**	70,85±14,48**b**	2,52±6,35**ab**
3	9,29±9,24**b**	18,61±13,93**a**	90,70±9,24**a**	67,82±19,60**b**	73,95±16,45**ab**	7,43±4,56**b**

Inc : Incubator; **NB :** Values with the same letter in the same column are not significantly different at the 5% threshold (p >0.05).

3.3.2. Egg hatching performance according to strains

Table 5 presents the egg hatching performances depending on the strains. For red flesh eggs, the embryonic mortality rate (18.70±13.25 %), the fertility rate (92.08±7.97 %), the apparent hatching rate (72.51±17.06 %) and the actual hatching rate (78.34±15.68 %) were higher than for Kuroiler eggs, with 15.76±13.37 % respectively; 90.91±8.08 %; 68.74±17.7 % and 75.37±16.62 %. However, the rate of clear eggs (9.08±8.08 %) and the rate of shell mortality (4.37±6.05 %) were higher for Kuroiler eggs compared to those of Rufous Flesh, with respectively 10.02±7.83 % for the clear egg rate and 2.94±4.54 % for the shell mortality rate. No significant difference (p>0.05) was observed between the egg incubation performance of the two strains of chickens.

Table 5 Egg hatching performance according to strains

Strains	**Clear egg rate**	**Embryonic mortality rate**	**Fertility rate**	**Apparent hatch rate**	**Actual hatching rate**	**Shell mortality**
Chair	7,91±7,97**b**	18,70±13,25**b**	92,08±7,97**b**	72,51±17,06**b**	78,34±15,68**b**	2,94±4,54**b**
Kuroiler	9,08±8,08**b**	15,76±13,37**b**	90,91±8,08**b**	68,74±17,7**b**	75,37±16,62**b**	4,37±6,05**b**

NB : Values with the same letter in the same column are not significantly different at the 5% threshold (p >0.05).

4. Discussion

This study carried out on the eggs of flesh breeders in the Yamoussokro District showed a significant difference (p<0.05) between the average weight and the diameter of the eggs of red flesh (51.54±5.3 g and 39, 50±2.91 mm) compared to Kuroilers eggs (50.02±5.54 g and 38.86±2.97 mm). This variation in weight and diameter could be explained by the size of the hens which influences the shape of the eggs. Indeed, red broilers are genetically larger than Kuroilers. According to Hy-line (2004), a positive and significant correlation is reported between the weight of the chicken and that of the egg. Travel et al. (2010) confirm that the weight of the egg increases considerably during the year of production, but that this evolution as well as the average weight of the egg depends on the hen lineage, particularly in relation to its body weight.

During our study the temperature varied in all three incubators, however these values remained consistent with the recommended values. For incubator 1, the temperature varied from 36.68°C to 37.62°C; for incubator 2, it fluctuated between 36.95 °C and 37.79 °C; for incubator 3, it oscillated between 36.82 °C to 37.91 °C. Certain factors such as temperature, humidity, ventilation and turning can influence egg incubation (MANE (2020). According to Molenaar et al. (2010), a temperature variation from 37.5 to 38.0 °C throughout the incubation period gives the best hatching results and chick quality. Our results are similar to those of Yoda (2011), who observed a variation from 37.7°C to 38. °C for its first incubator and from 37.2 °C to 37.6 °C for its second. As for Lourens et al (2005), they also obtained the best hatching results and the best chick quality when the temperature was maintained at 37.8 °C throughout the incubation period. According to these same authors, insufficient temperatures, such as 36.7 °C during the first week, can delay embryonic development and can compromise. the thermoregulation mechanisms of the chick during the first seven days following its placement. During our study, the humidity varied between 53.14 and 55.56 % for incubator 1, between 53.42 and 56.78 % for incubator 2 and between 54.49 and 65.35% for incubator 3. The first two incubators-maintained values consistent with the recommendations of Wageningen (2011), which recommends a humidity level between 50 and 60 % to guarantee an egg weight loss of 11 to 13 % after 18 days of incubation, thus promoting optimal results. This compliance could be due to the effectiveness of the humidity regulation system, such as the water tray, in these incubators. On the other hand, the third incubator displayed values exceeding this interval, which could have influenced the hatching results.

The fertility rate of incubator 1 was 89.07 %; 94.72 % for incubator 2 and 90.70 % for incubator 3. These results were higher than those of Yoda (2011) who obtained 68.9 %, as well as those of Akouango et al. (2010) who reported a fertility rate of 78.96 % for local hens. These differences could be explained by the quality of the breeders and that of the food used. However, Maliki et al., (2022) recorded a higher fertility rate (92.25 %), for eggs from Cou Nu chickens. For the apparent hatching rate, we obtained 76.95 % with incubator 1; 67.11 % for incubator 2 and 67.82 % for incubator 3. These results are lower than those reported by Maliki et al. (2022), who recorded a apparent hatch rate of 81.42 % for the first incubator and 77.25 % for the second incubator. They are also lower than that of Hantanirina et al. (2019), who obtained a apparent hatch rate of 90.16 % for native chickens in Madagascar. These differences could be explained by the quality of the incubators. The actual hatching rate (85.76%) of incubator 1 was significantly higher ($p<0.05$) than that (70.85 %) of incubator 2, while it was statistically identical ($p>0.05$) to that (73.95 %) of incubator 3. This superiority of the actual hatching rate of incubator 1 could be explained by the effectiveness of the fan responsible for dispersing the heat within the incubator, which, although alone, was larger and more sophisticated compared to the two small fans of the second incubator 2. Our results are superior to those of Eekeren et al. (2006) who reported a actual hatching rate of between 65 to 70 %. Concerning the embryonic mortality rate and the shell mortality rate, incubator 1 recorded the lowest embryonic mortality rate (13.20 %) and shell mortality rate (1.03 %). The shell mortality rate of incubator 1 was significantly lower than that of incubator 3 while no significant difference was observed between the other parameters of the incubators. Our embryonic mortality rate values are closer to those of Maliki et al. (2022) and Hantanirina et al. (2019), which obtained 10.37 % and 9.84 % respectively. This could be attributed to the incubation factors (temperature, humidity level and turning) in incubator 1. These results can be explained by the quality of the thermostat of this incubator, which allowed precise control of the temperature. In fact, the thermostat automatically adjusted the heating to maintain a stable temperature close to 37.7 °C and a humidity level of 54 %.

5. Conclusion

This study, aimed at comparing the performances of three incubators, two of which were artisanal and one industrially manufactured, revealed several significant results. In incubator 1, the temperature fluctuated from 36.68 °C to 37.62 °C and the humidity varied between 53.14 % and 55.56 %. Incubator 2 recorded a temperature ranging from 36.95 to 37.79 °C and a hygrometry between 53.42 to 56.78 %. As for incubator 3, the temperature varied from 36.82 to 37.91°C and the humidity was measured between 54.49 and 65.35 %. These incubation parameters made it possible to evaluate the hatching performance of the different incubators. Incubator 1, home-made, showed the best performance compared to the other two incubators. Indeed, she obtained an apparent hatching rate (TEA) of 76.95 % and an actual hatching rate (TER) of 85.76 %, with an embryonic mortality rate (EMR) of 13.20 %. and a shell mortality rate (CMR) of 1.03 %.

To further improve the performance of incubators, further studies could explore the importance of ventilation and air circulation in maintaining an optimal environment for embryo survival in incubators.

Compliance with ethical standards

Disclosure of conflict of interest

Authors have declared that no competing interests exist.

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