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Effect of storage duration on the hatching egg quality, embryonic parameters and post-hatch performance of Cherry Valley ducks

Auswirkung der Dauer der Bruteilagerung auf die Bruteiqualität, embryonale Parameter und die Leistung nach dem Schlupf von Cherry Valley Enten

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Abstract

Storage of incubating eggs is a normal and important practice after egg collection from the poultry house and often a necessity in hatchery management. However, egg storage duration and storage environmental conditions can affect egg quality and hatching parameters. The purpose of this study was to determine the effects of egg storage duration on egg quality, hatching parameters, and post-hatch performance of meat-type ducks. A total of 756 eggs were collected from a 32 weeks old breeder duck flock. Before incubation, the eggs were divided into three groups and were stored for 2, 7 or 14 d. At the end of the storage period, 7 eggs per treatment were examined to assess egg quality traits. Eggs were incubated for 28 d and hatching parameters were recorded. After hatching, the ducklings were reared according to their respective storage duration groups with 4 replicates and 15 birds per pen using a completely randomised design. Results showed that egg weight loss during storage was negatively influenced ($p < 0.05$) by prolonged duration. Storage of eggs for 14 days resulted in a decrease ($p < 0.05$) in Haugh unit and albumen weight and adversely affected embryo viability and hatchability. Extended egg storage duration did not affect ($p > 0.05$) egg weight loss during incubation. Embryo mortality was significantly higher ($p < 0.05$) for the eggs stored for 14 days. Post-hatch performance revealed that weight gain, feed conversion ratio, liver weight, and leg muscle were negatively affected ($p < 0.05$) by storage duration. It was concluded that the effect of egg storage duration on hatching trends in ducks are similar to that reported in chickens.

Key words

hatching eggs; egg storage; egg quality; hatchability; duck; performance

Zusammenfassung

Die Lagerung von Bruteiern ist eine normale und wichtige Praxis nach dem Sammeln der Bruteier im Geflügelstall und oft eine Notwendigkeit im Brütereimanagement. Die Dauer der Bruteilagerung und die Umgebungsbedingungen können jedoch die Qualität der Eier und die Schlupfparameter beeinflussen. Ziel dieser Studie war es, die Auswirkungen der Lagerungsdauer von Bruteiern auf die Eiqualität, die Schlupfparameter und die Leistung von Mastenten nach dem Schlupf zu bestimmen. Insgesamt wurden 756 Eier von einer 32 Wochen alten Zuchtentenherde untersucht. Vor der Bebrütung wurden die Eier in drei Gruppen mit unterschiedlicher Lagerungsdauer (2 Tage, 7 Tage oder 14 Tage) aufgeteilt. Am Ende des Lagerungszeitraums wurden 7 Eier pro Behandlung untersucht, um die Qualitätsmerkmale der Eier zu bewerten. Die Eier wurden 28 Tage lang bebrütet und die Schlupfparameter aufgezeichnet. Nach dem Schlupf wurden die Entenküken entsprechend der Bruteilagerungsgruppen mit jeweils 4 Wiederholungen und 15 Tieren pro Stall nach einem vollständig randomisierten Design aufgezogen. Die Ergebnisse zeigten, dass der Gewichtsverlust der Eier während der Lagerung durch die verlängerte Lagerdauer negativ beeinflusst wurde ($p < 0,05$). Eine 14-tägige Lagerung von Bruteiern führte zu einer Abnahme ($p < 0,05$) der Haugh-Einheit, des Eiklargewichts und wirkte sich negativ auf die Lebensfähigkeit der Embryonen und den Schlupf aus. Eine längere Lagerung der Eier hatte keinen Einfluss ($p > 0,05$) auf den Gewichtsverlust der Eier während der Inkubation. Die embryonale Mortalität war bei den 14 Tage gelagerten Eiern signifikant erhöht ($p < 0,05$). Die Leistung nach dem Schlupf zeigte, dass die Gewichtszunahme, die Futterverwertung, das Lebergewicht und die Beinmuskulatur durch die Lagerungsdauer negativ beeinflusst wurden ($p < 0,05$). Daraus wurde gefolgert, dass die Auswirkungen einer verlängerten Bruteilagerungsdauer auf Schlupf und Leistung bei Enten mit den bei Hühnern beschriebenen Effekten vergleichbar sind.

Stichworte

Bruteier; Eilagerung; Eiqualität; Schlupffähigkeit; Ente; Leistung

Introduction

Duck meat production, which has great value in Asian countries, is considered as a food resource and a source of animal protein. Ombansilar et al. (2007) reported that ducks have a high growth rate (3 kg live weight in 42 to 45 days) and high carcass yield. This performance is dependent on the strain, breeder management, and the quality of hatching eggs. The management of breeding stock plays an major role to ensure important hatchability. Breed used, season, health, and nutrition, and size, weight and quality of egg, in addition to the duration and storage conditions (Onasanya and Ikeobi, 2013) and incubation management are important (Tona et al., 2003). Egg storage duration is well known as an important factor that affects egg quality and hatchability. According to Abd el-hack et al. (2019), hatching egg storage condition and duration before incubation are the primary factors that affect egg quality, embryo development, hatching parameters, and day-old chick quality. Kustra et al. (2020) observed a significant decrease of hatchability of golden pheasants after 3 to 4 days of storage. Nasri et al. (2020) also reported that storage of chicken eggs for more than seven days alters the internal characteristics of the eggs, affects embryo development and survival, decreases hatchability, and reduces chick quality. Moreover, a hatching egg is a biological material containing all the essential nutrients for the developing embryo. All the nutrients, minerals, energy sources, and water utilised by the embryo are stored in the eggs by the laying breeders. This egg consists of three essential parts which are the egg yolk, the albumen, and the eggshell (Guha et al., 2018). The storage duration has an impact also on the internal egg quality and chick post-hatch juvenile growth (Decuypere et al., 2002). During storage, the physicochemical alterations of the yolk are mostly dependent on those described for albumen. Each part has a specific role in both embryo and postembryonic development. Embryo weight during incubation has been shown to be affected as well by the egg storage duration. Bakst et al. (2016) reported that a long storage reduced embryo weight compared to short day of egg storage. The storage of an egg for more than a week is known to increase abnormal embryonic mortality due to the degradation of the egg albumen viscosity (Petek and Dikmen, 2006). A longer period of egg storage also shows reduced hatchability and an increased incubation time. According to Tona et al. (2003), extended storage of eggs before incubation resulted in delayed hatching. This late hatching results from necrosis and morphological changes in the blastoderm (Decuypere et al., 2001) and a weight loss due to dehydration, reabsorption of the yolk sac, and protein catabolism, leading to restricted initial growth (Careghi et al., 2005).

To the best of our knowledge, most of the studies have focused on chicken hatching eggs and there is a paucity of information regarding the effect of egg storage duration on the hatching parameters and duckling postnatal growth. Therefore, the current research aimed to investigate the effects of storage duration on the hatching egg quality traits, embryo development, hatching parameters, and post-hatch growth performance of Cherry Valley ducklings.

Materials and Methods

The research was carried out following the guidelines of the Institute of Animal Ethics Committee of the Regional Centre of Excellence in Poultry Sciences (CERSA-UL).

Experimental design

A total of 756 fresh hatching eggs were obtained from 32 weeks old Cherry Valley duck breeder flock. The eggs were labeled and stored according to their storage groups as 2, 7, and 14 days at 12.5°C and 84.59% relative humidity before setting for incubation. The eggs were numbered and weighed individually before and after storage to determine egg weight loss during the storage period. At the end of the storage period, 7 eggs per each group were broken to determine egg quality characteristics. Shape index, eggshell weight, eggshell breaking strength, and shell thickness were measured. Yolk weight, and yolk colour; albumen height, albumen weight, and Haugh unit were also determined. Before incubation, the eggs were assigned to one of 4 replications of 63 eggs each according to the storage groups. The eggs were incubated in an EIan FeDMS incubator at 37.5°C, relative humidity of 62%, and turned each hour at an angle of 90°. At 12 d of incubation, all the eggs were candled and the infertile eggs were removed from the trays. At 24 d of incubation, the eggs were weighed, and those with evidence of living embryos were transferred from the turning trays to the hatching baskets. The weights measured were used to determine egg weight loss during incubation. The hatcher was operated at 37.0°C and 72% relative humidity until day 28 of incubation. All hatched ducklings were weighed and recorded. Eggs that failed to hatch were broken, opened, and visually evaluated to distinguish infertile eggs from eggs containing dead embryos. These data were used to calculate the hatching rate of the fertile eggs.

Eggs weight loss during incubation

At day 24 of incubation, all incubated eggs were weighed. These weights and those recorded prior to incubation were used to calculate relative egg weight loss up to d 24 of incubation as:

$$WL = \frac{W0 - W24}{W0} x100$$

Where: WL = relative egg weight loss; W0 = egg weight at setting; W24 = egg weight at day 24 of incubation.

Ducklings management

After hatching, the ducklings (270) were reared until 35 days of age according to the incubation treatments with 4 replicates of 15 birds each using a completely randomised design. Ducks were fed a starter diet for 2 weeks after which they were fed a grower diet. Feed and water were offered *ad libitum* during the experiment. The amount of feed consumed, body weight, and feed conversion ratio were recorded weekly. At 35 d of age, the feed was withdrawn before slaughter. A total of 36 ducks (2 ducks per replicate) were individually weighed to determine slaughter weight and then were slaughtered in the processing plant of the University farm. After slaughter, the organs were removed and weighed.

Statistical analysis

The data were processed with the SAS statistical software package (SAS Version 6.124). One way ANOVA model was used to analyse the effects of storage on egg weights, egg quality characteristics and egg components, durations of incubation; and post-hatch weights, duckling feed intake, body weight and feed conversion rate. The model was as follows:

$Yi = \mu + \alpha i + \varepsilon i,$

Where Yi = egg weights, egg quality characteristics and components, durations of incubation; and post-hatch weights duckling feed intake, body weight and feed conversion rate of the egg from storage time i, μ = overall mean, αi = the main effect of storage time i, εi = random error term from storage. Embryonic mortality and hatchability were analysed using a proc logistic procedure.

A probability value of 0.05 was used as the degree of significance. When the overall P-value was statistically different, the means were further compared among groups using Tukey's test.

Results

Egg weight and egg quality during storage and incubation

Table 1 shows the egg weight loss during storage and incubation, and egg quality parameters. In general, egg weight loss during storage increased with increasing egg storage duration. The egg weight loss during the storage was highest in eggs stored for 14 days (0.32 ± 0.05%) ($p < 0.05$) while those stored for 2 days had the lowest. Up to day 24 of incubation, relative egg weight loss was not affected by the storage duration (2, 7, and 14 days). The yolk weight and percent yolk (Table 1) from eggs stored for 2 and 7 days were significantly lower ($p < 0.05$) than that of eggs stored for 14 days. However, the yolk colour was similar for all groups. Albumen height was not affected by the storage time. However, the Haugh unit decreased with increasing egg storage duration. Haugh unit of eggs stored for 14 days was lower ($p < 0.05$) than those of eggs stored for 2 and 7 days. Albumen weight was also significantly affected by storage duration ($p < 0.05$). Albumen weight of eggs stored for 2 and 7 days were significantly higher ($p < 0.05$) than those of eggs stored for 14 days. The eggshell thickness, shell breaking strength, and shape index during storage of eggs did not differ ($p > 0.05$) among the storage groups.

Table 1. Egg quality parameters of incubating eggs after storage and during incubation

Qualitätsparameter von Bruteiern nach der Lagerung und während der Bebrütung

	Storage duration (days)		
Egg quality parameters	**2**	**7**	**14**
Egg weight loss during storage (%)	0.094 ± 0.00[a]	0.148 ± 0.01[b]	0.327 ± 0.05[c]
Egg weight loss during incubation (%)	12.83 ± 0.18	12.40 ± 0.05	12.30 ± 0.68
Yolk weight (g)	29.09 ± 0.78[b]	28.24 ± 0.51[b]	31.64 ± 0.72[a]
Yolk (%)	33.60 ± 0.94[b]	32.69 ± 0.54[b]	36.7 ± 0.80[a]
Yolk colour	9.43 ± 2.29	7.82 ± 2.12	8.9 ± 2.49
Albumen weight (g)	48.17 ± 0.87[a]	48.75 ± 0.44[a]	44.90 ± 0.67[b]
Albumen Haugh Unit	66.46 ± 2.42[a]	63.03 ± 1.12[ab]	61.96 ± 0.36[b]
Albumen height (mm)	5.91 ± 0.25	5.78 ± 0.25	5.53 ± 0.41
Shell weight (g)	10.78 ± 0.19	10.87 ± 0.13	11.19 ± 0.17
Egg shell thickness (µm)	36.62 ± 1.26	37.42 ± 1.46	37.14 ± 1.28
Egg shell breaking (kg-cm^{-2})	4.74 ± 0.21	4.72 ± 0.10	4.92 ± 0.17
Shape index	73.00 ± 0.34	73.8 ± 0.71	72.9 ± 0.48

[a,b] Differences in superscripts within rows indicate significant differences between the experimental groups.

Incubation parameters

Table 2 shows the hatching rate of all the eggs, fertile eggs, and the embryonic mortality. Hatchability of total eggs and fertile eggs was lower in eggs stored for 14 days ($p < 0.05$) due to high embryonic death.

Table 2. Effect of incubating egg storage duration on hatching performance

Einfluss der Lagerungsdauer der Bruteier auf die Schlupfleistung

Storage duration (days)	Hatchability (%)		Embryonic mortality (%)
	Total Egg	Fertile Egg	
2	88.17 ± 1.99[a]	96.00 ± 1.99[a]	3.99 ± 2.20[b]
7	89.38 ± 0.04[a]	95.21 ± 0.43[a]	4.78 ± 0.43[b]
14	83.68 ± 2.38[b]	89.13 ± 2.1[b]	10.86 ± 2.17[a]

[a,b] Differences in superscripts within rows indicate significant differences between the experimental groups.

Effect of storage on the growth performance of ducklings

Figure 1 shows the weekly body weight according to treatment and age of ducklings. Overall, body weight increased with the age of the ducklings. Between 1 and 3 weeks of age, duckling body weights were similar for all groups. From the 4–6 weeks of age, duckling weight from eggs of 14 days storage was significantly lower ($p < 0.05$) than those from eggs stored for 2 and 7 days.

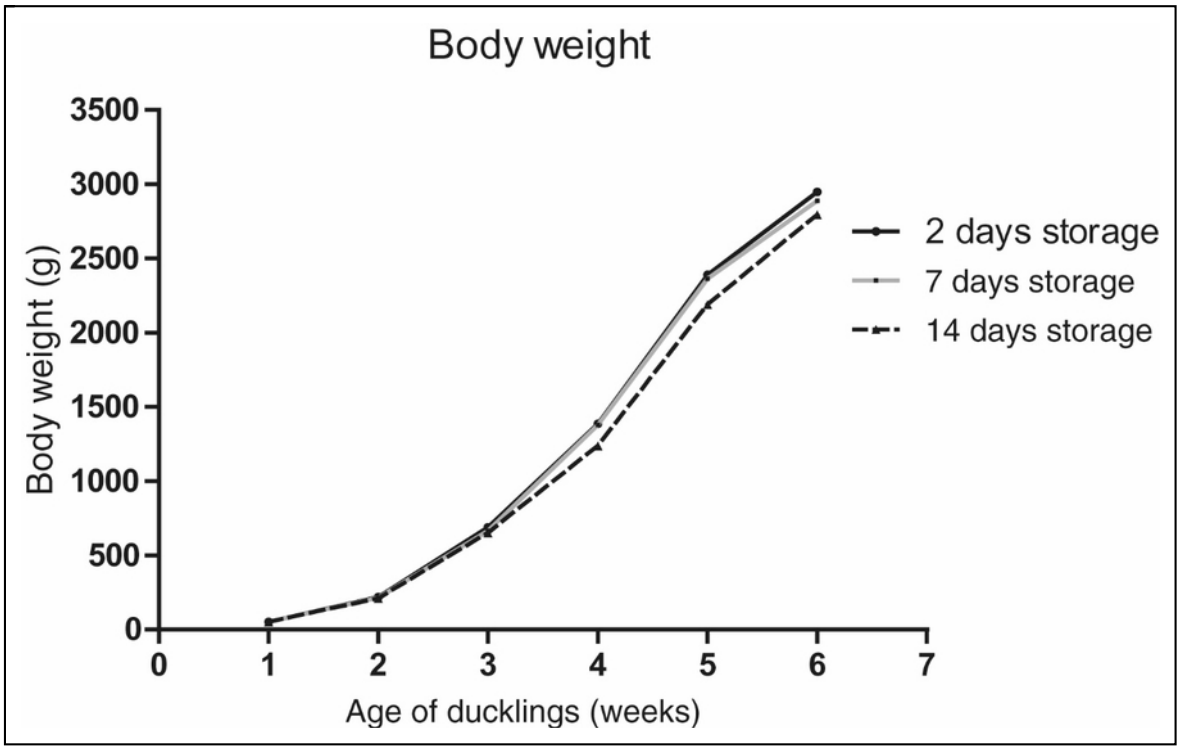

Figure 1. Absolute body weights of ducklings according to age and treatments

Absolute Körpergewichte der Entenküken in Abhängigkeit vom Alter und der Lagerungsdauer der Bruteier

Feed intake, weight gain, and feed conversion ratio

Daily feed intake was similar for ducks that hatched from 2 days and 7 days of egg storage and was significantly lower ($p < 0.05$) than that of the ducks that hatched from 14 days of egg storage (Table 3). Ducks' daily weight gain was similar for eggs stored for 7 days and 14 days, but a significantly higher ($p < 0.05$) weight gain was obtained from ducks that hatched from the 2 days storage duration group. However, the feed conversion ratio of the ducks that hatched from eggs stored for 2 days was lower ($p < 0.05$) than those of ducks that hatched from 7 days and 14 days egg storage groups.

Table 3. Feed intake, weight gain, and feed conversion ratio of ducklings related to incubating egg storage duration

Futteraufnahme, Gewichtszunahme und Futterverwertung der Entenküken in Abhängigkeit von der Lagerungsdauer der Bruteier

	Storage duration (days)		
Parameters	**2**	**7**	**14**
Feed intake (g/day)	233 ± 2.72[a]	232 ± 0.04[a]	241 ± 2.02[b]
Weight gain (g)	83.00 ± 1.31[a]	77.00 ± 1.50[b]	76.59 ± 1.16[b]
Feed conversion ratio	2.81 ± 0.05[b]	3.14 ± 0.31[a]	3.17 ± 0.13[a]

[a,b] Differences in superscripts within rows indicate significant differences between the experimental groups.

Slaughter parameters

The effects of egg storage on slaughter parameters of Cherry Valley ducks are shown in Table 4. The liver, abdominal fat, and leg muscle were significantly affected by the storage of eggs before incubation. The liver and leg muscle weights were significantly higher ($p < 0.05$) in ducks from eggs stored for 2 and 7 days than those of ducks from eggs stored for 14 days. The highest abdominal fat weight was obtained from eggs stored for 2 and 14 days compared to the 7 days storage duration group ($p < 0.05$). However, there was no significant difference ($p > 0.05$) among the weight of all the other parameters despite the differences in the storage duration of eggs.

Table 4. Effect of incubating egg storage duration on slaughter parameters

Einfluss der Lagerungsdauer der Bruteier auf die Schlachtparameter

	Storage period (days)		
Relative weight (%)	**2**	**7**	**14**
Heart	0.541 ± 0.01	0.560 ± 0.01	0.553 ± 0.01
Liver	1.84 ± 0.04[a]	1.87 ± 0.05[a]	1.75 ± 0.02[b]
Spleen	0.077 ± 0.00	0.064 ± 0.00	0.072 ± 0.00
Fat	1.41 ± 0.09[a]	1.29 ± 0.09[b]	1.48 ± 0.09[a]
Breast muscle	4.93 ± 0.18	5.09 ± 0.18	5.12 ± 0.23
Leg muscle	4.51 ± 0.06[a]	4.64 ± 0.14[a]	4.22 ± 0.08[b]
Duodenum weight (%)	0.468 ± 0.01	0.742 ± 0.01	0.491 ± 0.01
Duodenum length (cm)	34.23 ± 0.81	33.85 ± 0.55	35.31 ± 0.53
Jejunum weight (%)	2.02 ± 0.05	2.04 ± 0.04	2.25 ± 0.07
Jejunum length (cm)	154 ± 2.81	154 ± 3.27	155 ± 2.5
Ileum weight (%)	0.172 ± 0.00	0.194 ± 0.01	0.186 ± 0.00
Ileum length (cm)	16.69 ± 0.59	18.05 ± 0.56	17.09 ± 0.39

[a,b] Differences in superscripts within rows indicate significant differences between the experimental groups.

Discussion

The storage of eggs can affect the internal egg quality, hatchability, and the overall performance of the bird. The storage of hatching eggs is an important practice after egg collection or before egg incubation, but environmental conditions and egg storage duration can affect egg quality and hatching performance. In this study, egg weight losses during storage were significantly affected by egg storage duration. The longer the eggs were stored, the higher the egg weight loss. This is not unexpected as it has been shown in a number of chicken-related studies that long time storage would increase the opportunity for water vapor to escape from the eggs (Alpay and Petek, 2016). These results are in contrast to the findings of Tilki and Saatci (2004) and Petek and Dikmen (2006). Differences in egg weight losses may be explained by differences in the egg's external shell quality, the humidity levels used during storage and the differences in management practice.

There was a negative effect of egg storage on the albumen weight and Haugh unit. Albumen weight declined progressively with prolonged storage duration and was lowest in the eggs stored for 14 days. A similar trend was observed for the Haugh unit. These findings are similar to previous findings by JONES et al. (2002), TONA et al. (2003), and JONES and MUSGROVE (2005) for chicken eggs and OMBANSILAR et al. (2007) for Pekin duck eggs. These authors reported that increased egg storage duration depressed egg internal quality, especially albumen quality. SAMLI et al. (2005) showed that storage time adversely affected the Haugh unit in chicken eggs. It is well known that a longer storage time decreases Haugh unit, due to loss of water (MARTÍNEZ et al., 2014). Additionally, SAMLI et al. (2005) showed that most of the changes in egg quality in terms of Haugh unit and albumen height could be attributed to the moisture loss by evaporation through the shell pores and the escape of CO_2 from the albumen.

Yolk weight and yolk percentage during storage were significantly affected by the storage duration. It was higher in the eggs stored for 14 days. Albumen weight decreased and yolk weight increased with storage time. These results agree with that of SILVERSIDES and SCOTT (2001), who reported that longer periods of storage resulted in greater percentages of eggshell and yolk and a lesser percentage of albumen in chicken eggs. This result is consistent with OMBANSILAR et al. (2007) for Pekin duck eggs. These authors pointed out that when the storage period is extended, the internal quality of duck eggs progressively declines due to the loss of moisture from the egg. OMBANSILAR et al. (2007) working with Pekin ducks, and AKYUREK and OKUR (2009) using layer chickens reported that albumen and yolk weights did not change with storage duration. In the current study, egg weight loss during incubation was not affected by storage duration. The amount of loss in percentage conforms with the values generally observed in chicken eggs.

Hatching parameters and embryo mortality were affected by the length of storage. Hatchability of total eggs and fertile eggs was lower and embryonic death was higher in the eggs stored for 14 days. This is consistent with previously reported studies in chickens, which indicated that egg storage duration adversely affects embryo viability and hatchability (POKHREL et al., 2018). According to PETEK and DIKMEN (2006) and KHAN et al. (2014), most embryonic deaths are observed in broiler breeder eggs stored for 15 days. Other researchers reported that embryonic death increase with increasing egg storage period (ELIBOL et al., 2002; PETEK et al., 2005). In another study, storage time linearly influenced hatchability and embryonic mortality (SCHMIDT et al., 2009). It is advisable not to store eggs for more than two weeks, as hatchability decreases significantly during a long period of egg storage. It has been shown that storage period is related to both early and late embryonic deaths (OMBANSILAR et al., 2007). The embryonic death was higher due to loss of water and degradation of albumin during storage (ABD EL-HACK et al., 2019). These effects of storage may be explained by the deterioration of the egg internal quality, especially water loss and Haugh unit degradation during the storage period (UYANGA et al., 2020). This degradation causes the blastoderm to move into proximity to the eggshell so that embryonic mortality results from dehydration during incubation (UYANGA et al., 2020).

The results showed that egg storage duration had no significant effect on the weight of day-old ducklings. Some researchers (TONA et al., 2004; PETEK et al., 2005) showed that chicks hatched from similar egg weights stored for different days had similar initial weights. However, eggs stored for long duration had negative effect on 35 days bodyweight, relative growth, and feed conversion ratio in chickens. This result is consistent with the reports of TONA et al. (2003) and OMBANSILAR et al. (2007) who noted that longer periods of storage negatively affected the bird's growth, daily growth gain, and feed conversion ratio. PETEK and DIKMEN (2006) also noted an increase in feed conversion ratio with an increase in egg storage duration.

The present study demonstrated that ducks from eggs with a longer period of storage (14 d) had lower leg muscle and liver weights. The negative effect of longer periods of egg storage on the liver weight and leg muscle from eggs stored for 14 days may have been positively correlated with the effect of egg storage on embryo organ development (NASRI et al., 2020). It is known that between 5 and 19 days of storage, yolk body mass and liver percentage decreased, as well as hatchling length and yolk efficiency (NASRI et al., 2020). The results of the present study indicated that egg storage duration did not affect the weight and length of the duodenum, jejunum, and ileum. These results disagree with those of YALCIN et al. (2016, 2017) who reported that a longer period of egg storage negatively affected intestinal morphology, weight, and length.

Conclusion

In conclusion, prolonged egg storage duration negatively affected egg internal quality, especially albumen quality, reduced hatchability, and increased embryonic death. Egg storage duration also affected weight gain, and feed ratio conversion of ducks until 35 days post-hatch. Longer periods of storage had negative effect on liver weight and leg muscle. Further study is recommended on the interaction between egg storage duration and Cherry Valley breeder duck age on egg internal quality, hatching parameters, and their growth performance.

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Author's contributions

Nideou. D: Experiment design, data collection, analysis and interpretation, drafting of the article.

O. Moubinou: Assistance for data collection.

Y.A.E. Kouame: Assistance for data collection.

O. Onagbesan: Language and critical revision of the manuscript.

H. Lin: Supervision of experimental critical revision of the manuscript.

K. Tona: Approval of the experimental design, critical revision of the manuscript and final approval of the version to be published.

Conflict of Interest

The authors declare no competing interests.

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