Effects of breeder age on embryonic development, hatching results, chick quality, and growing performance of the slow-growing genotype

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ABSTRACT The present study aimed to ascertain the effects of slow-growing breeder age on embryo development, incubation results, and chick quality and of the interaction between breeder age and hatching time on initial performance. A total of 630 hatching eggs obtained from a commercial flock of slow-growing broiler breeders (Isa Label Naked Neck) were evaluated in 2 experiments. The first experiment evaluated embryo development and hatching results for broiler breeder age treatments of 38 and 51 wk, whereas the second experiment evaluated broiler chick performance. For the second experiment, chicks were distributed in a 2 x 2 factorial randomized block (sex) experimental design consisting of 2 breeder ages (31 or 58 wk) and 2 hatching times (479–485 and 491–497 h). At 18 d of embryonic development, embryos of 51-wk-old breeders were larger than those of 38-wk-old breeders ($P < 0.05$), whereas yolk-free chick weight was similar ($P > 0.05$). Embryo organ weight was similar for the 2 breeder ages ($P > 0.05$); however, there was greater development of intestinal villi for embryos of the 51-wk-old breeders. There were no differences between breeder ages in hatchability and chick quality score ($P > 0.05$). Yolk-free chick weight at pulling was greater ($P < 0.05$) for chicks from 51-wk-old breeders. Hatching time did not affect performance from 1 to 7 d ($P > 0.05$); however, chicks hatching at 491–497 h had better performance from 1 to 28 d than did chicks hatching at 479–485 h ($P < 0.05$). In conclusion, the age of slow-growing breeders affects embryo villi development and chick weight but does not improve incubation results or chick quality. Chicks hatching later (491–497 h) had better performance results than chicks hatching earlier (479–485 h).

Key words: breeder age, embryo development, free-range broiler, hatching time, naked-neck strain

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INTRODUCTION

Demand for meat from free-range broiler production has been increasing in several countries (Devatkal et al., 2018). The sensorial characteristics of this type of meat differ from those of other fast-growing broiler chickens, and parameters such as skin color, tenderness, water-holding capacity, and protein content are indicated as better (Sun et al., 2013). In addition to the characteristics of the meat, consumers believe that free-range access is important for broiler chicken welfare (Vanhonacker et al., 2012). These peculiarities add value to the product by serving a range of more-demanding consumers (Takahashi et al., 2006). The free-range broiler chicken production chain in Brazil was organized to define the term "slow growth" of broilers. Thus, several regulations must be considered, including required use of slow-growing strains and access to paddocks for chickens at 30 d of age (ABNT, 2015).

Some slow-growing broiler strains have been created in Brazil, including Isa Label Naked Neck (Figure 1), which has a double aptitude—it is considered a good layer and rustic yet has meat with a much-appreciated flavor (Carrijo et al., 2002). Nonetheless, there remains a limitation regarding the availability of day-old slow-growing chicks for substitution in farms, especially with regard to their genetic, physical, and immunologic quality. To ensure the quality of neonate chicks on the market, characteristics of this strain need to be studied, along with the factors that affect embryonic development and consequent yield in the incubator.

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Artificial egg incubation is an important step in the poultry production chain, with its results directly affecting the profitability of the entire chicken meat production segment (Araújo et al., 2016).

Several factors can affect hatchery production rates, with breeder age being one such factor that must be considered in hatchery management (Tona et al., 2001). Changes occur in the constituents of eggs as breeders age, which can affect the embryonic mortality rate and, consequently, hatching percentage (Peebles et al., 2001). Industrial breeders produce, at the beginning of the laying process, eggs with thick shells, fewer pores, and dense albumen, characteristics that reduce moisture loss and gas exchange, which can compromise embryonic development in the early stages and reduce subsequent hatching rates (Araújo et al., 2017). On the other hand, industrial broiler chicks hatch in a time span of 480 to 510 h (Araújo et al., 2016). Technicians of commercial hatcheries consider hatching time for chick removal to be approximately 504 h, which supposedly maximizes hatching (El Sabry et al., 2013). Breeder age is considered to be a factor that affects the hatching time, with the effects being different between the young and old breeders (Tona et al., 2001; Araújo et al., 2016). Chicks that hatch early remain for several hours in the hatcher without access to water and feed and exposed to temperatures higher than the appropriate level. Such factors can lead to processes of dehydration and losses in chick performance during the rearing phase (Jong et al., 2016).

Performance of industrial broilers during the growth phase can be influenced by newborn chick quality. Heavier chicks with a higher growth rate from older broilers result in chickens with better feed conversion, lower mortality, and greater weight gain (Hulet et al., 2007; Muerer et al., 2008; Fernandes et al., 2014).

In addition, morphologic changes occur in relation to intestinal development after hatching, which are dependent on the first access to food and include the differentiation of enterocytes, definition of crypts, and increases in the absorptive surface of the intestine (Uni et al., 2003). In this way, posthatching fasting reduces the proliferation of enterocytes and the size of villi, which results in impaired intestinal function and, consequently, chicken performance Cardeal et al. (2020).

Considering that breeders of slow-growing strains respond differently to several aspects of production when compared with fast-growing breeder strains, the present study aimed to evaluate the effects that age of slow-growing broiler breeders has on embryonic development, hatching performance, and chick quality. This study also aimed to evaluate the effect of the age of the slow-growing broiler breeders and the hatching time on performance at 28 d.

MATERIAL AND METHODS

All procedures used in the experiments of this study received prior approval from the Animal Ethics Committee of the Federal University of Goiás, Brazil (Protocol 119/2017).

Incubation

Two experiments were performed using a total 630 hatching eggs obtained from 2 commercial flocks of slow-growing broiler breeders (Isa Label Naked Neck): 1 with 38-wk-old breeders (young breeders) and 1 with 51-wk-old breeders (old breeders). The breeders were fed diets that were prepared following recommendations for this strain.

Eggs were stored at 16°C and 75% RH for 2 d and warmed to room temperature (22°C) before setting. The eggs of the 38-wk-old and 51-wk-old broiler breeders weighed 59.00 (±8.81) g and 65.79 g (±9.86), respectively. Experiment 1 evaluated embryo characteristics, hatchability, residual analysis, and chick quality. The experimental design consisted of randomized blocks (3 setters), with 2 breeders age and 9 repetitions (trays). The trays held 70 eggs, so it was completed with 35 eggs from each treatment for a total of 315 eggs per treatment.

The eggs were incubated in 3 single-stage setters (Gaiolas Almeida) with 3 trays and a total capacity of 273 eggs each. The setters were set to maintain incubation patterns at 37.5°C and 60% RH. Eggs were turned at an angle of 45° at a frequency of 24 times/d. All eggs were candled at 18 d of incubation to remove infertile eggs and eggs with early embryonic mortality.

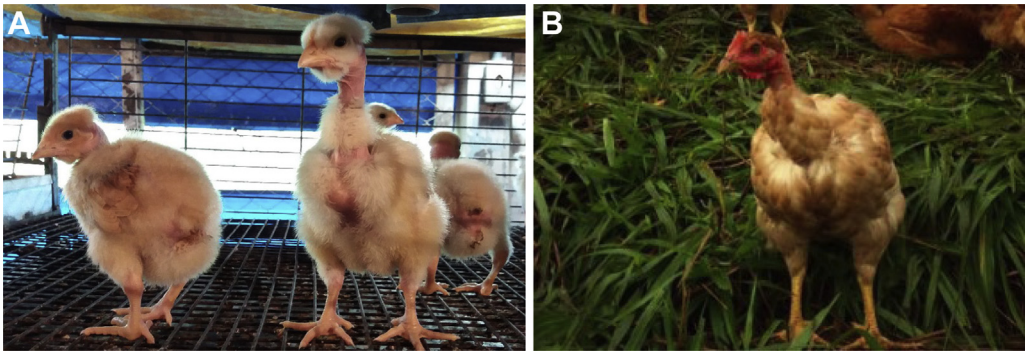

Figure 1. Isa Label Naked Neck Broilers. (A) Chicks at 7 d. (B) Chick at 28 d.

A sample of 12 eggs was randomly selected from each setter to measure embryo characteristics. A total of 588 eggs were then transferred to hatchers baskets (34 eggs of each treatment), and the setter was set to maintain the temperature and RH of the hatchers at 36.5°C and 70%, respectively, with stop turning. These eggs were then placed individually in an air-permeable fabric bag for treatment control.

Experiment 1: Embryo Characteristics

Embryos were euthanized by cervical dislocation and subsequently weighed using a 0.001-g precision analytical balance. The length of the gastrointestinal tract (cm) was measured from the insertion of the esophagus into the oropharynx to the communication of the large intestine with the cloaca. The following organs were weighed: proventricle plus gizzard; pancreas; small intestine (end of the muscular stomach to beginning of the cecum); large intestine (cecum, colon, and rectum); liver (without gall bladder); and heart. Percentage residual yolk sac weight was calculated by dividing absolute yolk sac weight by free yolk chick weight and multiplying by 100, while percentage organ weight for the various organs was calculated by dividing absolute organ weight by free yolk chick weight by and multiplying by 100.

To investigate intestinal development, histologic slides were made of the small intestine (duodenum and jejunum), as described by Luna (1968). Intestinal histomorphometry were used ten measurements of villus height and crypt depth. Were performed for each intestinal segment (duodenum and jejunum) per bird (12 per treatment), resulting in 120 measurements of villus height and 120 measurements of crypt depth per intestinal segment per treatment. The measurements were then used to calculate the villus/crypt ratio. Measurements were made using an optical microscope (5 ×) coupled to an image analyzer system (AxioVision 3.0; Zeiss).

Experiment 1: Hatchability, Residual Analysis, and Chick Quality

Hatching rate was determined as the ratio of the number of hatched chicks per number of fertile incubated eggs, with the fertility rate for eggs from 38-wk-old and 51-wk-old breeders being 97.69 and 98.68%, respectively. Hatching was monitored from 461 h to 509 h of incubation. The hatch window comprised the period between the first and last chick hatched in each basket (461–509 h of incubation). The hatcher was opened every 6 h to count the number of hatched chicks, after which the basket was returned to the hatcher and the hatcher closed. All chicks were kept in the hatcher until pulling at 509 h.

Unhatched eggs at the end of the hatch window were submitted to residual analysis considering 4 stages of embryonic mortality according to Araújo et al. (2016). Chick physical quality was evaluated for all hatched chicks by individually weighing them at hatching (considering feather drying during each hatch window) and after pulling (509 h). The chicks were then scored for physical quality using the system proposed by Tona et al. (2003), with chicks being the experimental unit. Still was considered chick weight at pulling (509 h) and free yolk weight body (g).

Experiment 2: Performance

To determine performance, the chicks were divided into 2 groups as per the hatching time: early (479–

Table 1. Composition and calculated nutritional values of the diets.

	Age (d)	
Ingredients (%)	1 to 7	8 to 28
Corn 7.26% CP	57.55	62.98
Soybean meal 47% CP	37.07	32.39
Dicalcium phosphate	1.91	1.46
Soybean oil	1.28	1.10
Limestone 37% Ca	0.89	0.96
Common salt	0.50	0.46
DL-Methionine 99%	0.35	0.27
L-Lysine 98%	0.30	0.23
Mineral vitamin supplement [1]	0.10	0.10
Total	100.00	100.00
Chemical composition (analyzed on dry matter basis; g kg^{-1} of DM)		
ME (kcal/kg)	2,925.00	2,980.00
Crude Protein %	21.80	20.00
Calcium %	0.920	0.827
Available phosphorus%	0.470	0.381
Dig. Lysine %	1.297	1.135
Met + cys dig. %	0.934	0.818
Sodium %	0.22	0.205

[1]Composition per kilogram of the product: vitamin A, 13,4440.000 UI; vitamin D3, 3,200.00 UI; vitamin E, 21,000 UI; vitamin K3, 2,880 mg; vitamin B1, 500 mg; vitamin B2, 9,200 mg; vitamin B6, 4,992 mg; vitamin B12, 3,000 mg; niacin 67.20 g; folic acid, 1,600.00 mg; pantothenic acid, 24.96 mg; biotin, 80.0 mg; manganese, 150.0 g; zinc, 140.0 g; iron, 90.0 g; copper, 15.0 g; iodine, 1,500.0 mg; selenium, 600.0 mg; cobalt, 50 mg.

Table 2. Organs and gut characteristics of slow-growing broiler chickens embryos (18 d) as per breeders age.

	Breeders age (wk)			
	38	51		
Items	Weight (g)		*P*-value	SEM
Embryo weight	39.71[b]	41.44[a]	0.042	0.16
Free yolk embryo weight	28.28	28.74	0.403	0.37
	Weight (%)		*P*-value	SEM
Yolk sac	40.43	40.35	0.178	0.14
Heart	0.62	0.62	0.968	0.03
Proventricle plus gizzard	5.40	4.98	0.081	1.22
Liver	1.86	1.85	0.094	0.11
Duodenum plus pancreas	0.38	0.38	0.891	0.10
Jejunum	0.48	0.53	0.415	0.08
Ileum	0.41	0.50	0.236	0.10
Large intestine	0.52	0.54	0.715	0.17
	Length (cm)		*P*-value	SEM
Duodenum	5.10	4.89	0.351	0.17
Jejunum	9.24	9.06	0.818	0.08
Ileum	8.12	9.09	0.126	0.91
Large intestine	4.51	4.15	0.075	0.50

[a,b]Means within the same row with different letters are significantly different by F test ($P < 0.05$).

Table 3. Intestinal mucosal morphometry of slow-growing broiler chicks embryos at 18DE from breeders of different ages.

	Breeders age (wk)			
	38	51		
Items	Duodenum		*P*-value	SEM
Villus (µm)	210,02	202,38	0.435	8.24
Crypt (µm)	15.05[b]	19.69[a]	<0.001	1.10
Villus:crypt	15.05[a]	10.68[b]	<0.001	5.00
	Jejunum		*P*-value	SEM
Villus (µm)	130.88	127.50	0.709	3.01
Crypt (µm)	16.45	16.33	0.870	3.97
Villus:crypt	9.03	9.76	0.345	0.99

[a,b]Means within the same row with different letters are significantly different by F test ($P < 0.05$).

485 h) and late (491–497 h). Chicks hatched at other times were not considered for performance. The trial was completed at 509 h with all chicks (early and late) being removed at the same time.

Chicks were distributed in a 2 x 2 factorial randomized block (sex) experimental design consisting of 2 breeder ages (31 or 58 wk of age) and 2 hatching times (479–485 h and 491–497 h). A total of 384 1-day-old chicks (38.78 ± 3.88 g) from the incubation experiment were distributed into 4 treatments with 4 replicates per sex, for a total of 16 experimental units with 12 birds each. One hundred ninety-two male chicks and 192 female chicks were used and divided between the 4 treatments. Birds were housed in galvanized-steel battery cages (0.5 m × 0.4 m × 0.4 m), equipped with trough drinkers and feeders. The birds received 24 h of artificial light for the first 14 d, after which they received natural light (12 h) until the end of the experiment. Water and feed were provided ad libitum. Birds were fed corn and soybean meal–based diets formulated to supply their nutritional requirements during the prestart (1–7 d) and start phases (8–28 d), according to Rostagno et al. (2011) for regular broiler chickens, with adaptation (Table 1). Feed consumption, weight gain, and mortality were recorded at the end of each wk. The performance indexes used were final weight, feed consumption, feed conversion, weight gain, and viability.

Statistical Analysis

Data were evaluated for normality using the Shapiro-Wilk test and then subjected to ANOVA with comparison of means by the F′ test (quantitative) and Mann-Whitney test (qualitative), with a significance level of 0.05. All analyses were conducted using R software, version 3.4.4 (2017).

Table 4. Hatching results of slow-growing broiler chicks as per breeders age.

	Breeders age (wk)			
Items	38	51	*P*-value	SEM
Eggs loss weight (%)	11.28[b]	11.73[a]	0.037	0.11
Hatchability/fertile (%)	85.50	82.29	0.538	2.89
Hatch Window (h)	24.97[b]	26.72[a]	0.009	1.78
Chick weight at pulling (g)	36.33[b]	39.39[a]	0.026	1.98
Free yolk chick weight at pulling (g)	33.14[b]	35.79[a]	0.029	1.11

[a,b]Means within the same row with different letters are significantly different by F test ($P < 0.05$).

RESULTS

Experiment 1: Embryo Characteristics

There were no significant differences in average free yolk embryo chick weight, percentage of heart, percentage of proventricle plus gizzard, percentage of liver, percentage of duodenum plus pancreas, percentage of jejunum, percentage of ileum, and percentage of large intestine among the treatments ($P > 0.05$). The embryo weight from 51-wk-old breeders was greater than that of the 38-wk-old breeders ($P < 0,05$) (Table 2). Young breeders had lesser crypt depth and higher villus:crypt ratio in the duodenum than did old breeders ($P < 0.05$).

Breeder age did not affect ($P > 0.05$) the other histologic parameters evaluated at 18 d of embryonic development (Table 3). Breeder age affected chick weight at pulling ($P < 0.05$), with chicks from old breeders being heavier than those from young breeders (Table 4).

Experiment 1: Hatchability, Residual Analysis, and Chick Quality

There was greater weight loss between incubation and transfer for eggs from old than from young breeders ($P < 0.05$). Chicks from eggs from old breeders had greater hatching/fertility, larger hatch window, greater weight at pulling, and greater yolk free weight than chicks from eggs of young breeders ($P < 0.05$) (Table 4). Breeder age did not affect ($P > 0.05$) infertility rates and residual analysis (Table 5).

Breeder age affected the intestinal development of embryos. Chicks form old breeders had taller villi and shallower crypts in the duodenum than did chicks from young breeders. The villus:crypt ratio for the duodenum was higher for chicks from young than for old breeders ($P < 0.05$). Breeder age had no effect ($P > 0.05$) on

Table 5. Residual analysis (%) of unhatched eggs as per slow-growing broiler breeders age relative to the total number of incubated eggs.

	Breeders age (wk)		
Diagnosis (%)	51	38	*P*-value
Infertile eggs	1.32	2.31	0.9874
MI	1.65	1.65	1.000
MII	0.66	0.33	1.000
MIII	0.99	0.99	1.000
MIV	10.23	12.87	0.6580
Pipped, alive	3.63	1.65	0.9774
Pipped, dead	2.31	1.32	0.9874
Contaminated eggs	0.33	0.00	1.000

Abbreviations: MI, mortality from 0 to 4 d of embryo development; MII, mortality from 5 to 10 d of embryo development; MIII, mortality from 11 to 17 d of embryo development; MIV, mortality from 18 to 21 d of embryo development.

Table 6. Effect breeders age on intestinal mucosal morphometry of slow-growing broiler chicks at pulling.

	Breeders age (wk)			
	38	51		
Items	Duodenum		*P*-value	SEM
Villus (μm)	401.52[b]	498.00[a]	<0.001	51.0
Crypt (μm)	61.13[a]	53.12 [b]	0.007	25.9
Villus:crypt	6.88[b]	10.72[a]	<0.001	5.5
	Jejunum		*P*-value	SEM
Villus (μm)	283.06	297.49	0.420	15.5
Crypt (μm)	43.00	42.90	0.751	2.2
Villus:crypt	7.85	7.87	0.797	3.3

[a,b]Means within the same row with different letters are significantly different by F test ($P < 0.05$).

histomorphometry of the jejunum (Table 6). Breeder age had no effect on chick quality score ($P > 0.05$) (Table 7).

Experiment 2: Performance

During the period of 1 to 7 d, there was an interaction between factors ($P < 0.05$) for BW (Table 8). In addition, chicks from old breeders had higher feed intake and BW gain than did chicks from young breeders ($P < 0.05$). Hatching time did not affect performance during the period of 1 to 7 d ($P > 0.05$).

During the period of 1 to 14 d, there was an interaction between factors ($P < 0.05$) for feed intake (Table 8). In addition, chicks from old breeders had greater weight gain and BW than did chicks from young breeders ($P < 0.05$). Hatching time did not affect performance during the period of 1 to 14 d ($P > 0.05$). Chicks from young breeders that hatched later (491–497 h) were heavier at 7 d than those that hatched earlier (479–485 h) (Table 9). On the other hand, chicks from old breeders with different hatching times did not differ in weight at 7 d.

Chicks from young breeders that hatched late (491–497 h) had higher feed intake at 14 d than did those that hatched early (479–485 h) (Table 10). On the other hand, chicks from old breeders with different incubation periods did not differ in feed intake at 14 d.

There was no interaction among the factors ($P > 0.05$) for the performance variables from 1 to 21 d and from 1 to 28 d (Table 11). Chicks from old breeders had greater weight gain and greater BW that did those from young breeders during the period of 1 to 21 d ($P < 0.05$). Chicks that hatched later had greater weight gain and greater BW than chicks that hatched later in the period of 1 to 21 d ($P < 0.05$), which was maintained from 1 to 28 d ($P < 0.05$).

DISCUSSION

A review of the literature found few studies with slow-growth broiler breeders. Thus, the results of the present study can provide help in choosing the best incubation management to ensure higher productivity in commercial hatcheries. The results obtained in the experiments demonstrated how the age of slow-growth broiler breeders could affect artificial incubation results, hatching rates, and chick quality.

Yolk-free embryo weight was high for embryos from old breeders. According to Iqbal et al. (2016), heavier embryos are expected from eggs of older breeders because their eggs are larger. Nonetheless, yolk sac weight tends to be heavier for embryos from older breeders (El Sabry et al., 2013; Araújo et al., 2016).

This response, however, was not found for the slow-growing breeders of the present study. This result is in disagreement with Sklan et al. (2003), who reported that heavier eggs result in larger embryos, although embryo organs were also not influenced by hen age. On the other hand, Nangsuay et al. (2016) also did not observe an effect of breeder age (29–30 wk and 54–55 wk), at 18 d of embryonic development, on yolk-free chick weight or on yolk sac weight. This may be is because the age range used in the present study was similar to that reported in the study by Nangsuay et al. (2016). In addition, the average egg weight from slow-growing breeders is lower than that of fast-growing breeders within the same age range (Alsobayel et al., 2013; El Sabry et al., 2013).

In the present study, embryos in the last stage of development (19–21 d) from old breeders made more use of the yolk sac, which resulted in greater tissue gain when compared to embryos from young breeders. The use of nutrients present in eggs is fundamental to greater development of embryos (Yang et al., 2020), and embryos from older breeders tend to make better use of the nutrients present in the egg (Araújo et al., 2016). The higher conductance of eggshells of older breeders, which allows greater oxygen entry, may have favored beta-oxidation of the yolk sac and, consequently, the use of the nutritional contribution of the egg yolk (Araújo et al., 2017). This greater embryonic metabolism may explain the lower yolk sac weight and the greater development of embryos from older breeders.

Table 7. Score quality (0 to 100 points[1]) of newly hatched slow-growing broiler chicks according to breeders age.

	Quality score			
Breeders age (wk)	<70 points (%)	71–80 points (%)	81–90 points (%)	91–100 points (%)
38	0.00	2.03	9.72	88.24
51	0.46	0.74	9.29	89.49
P-value	1.000	0.885	0.921	0.830
SEM	0.29	0.82	1.10	4.21

[1]Score adapted of Tona et al. (2003).

Table 8. Effect of breeders age and hatching time on growth performance of slow-growing broiler chicks.

	1 to 7 d of age				
Items	Feed intake (g)	Feed convertion ratio (g/g)	BW gain (g)	BW (g)	Viability (%)
Breeders age (wk)					
38	92.4[b]	1.355	68.3[b]	106.9	96.1
51	99.5[a]	1.353	73.7[a]	113.3	98.2
Hatching time					
479–485 h	94.7	1.376	69.0	107.0	97.7
491–497 h	97.1	1.332	72.9	113.0	97.0
P-value					
Breeders age	0.018	0.964	0.047	0.020	0.255
Hatching time	0.391	0.129	0.150	0.028	0.673
Age x Hatching time	0.103	0.620	0.093	0.040	0.794
SEM	7.93	0.02	5.86	6.31	4.21

	1 to 14 d of age				
Items	Feed intake (g)	Feed convertion ratio (g/g)	BW gain (g)	BW (g)	Viability (%)
Breeders age (wk)					
38	347.5	1.635	212.4[b]	250.8[b]	96.1
51	359.5	1.617	222.2[a]	261.7[a]	97.4
Hatching time					
479–485 h	348.2	1.620	214.8	252.6	96.5
491–497 h	358.7	1.632	219.7	259.9	97.0
P-value					
Breeders age	0.056	0.480	0.029	0.015	0.418
Hatching time	0.092	0.643	0.255	0.091	0.788
Age x hatching time	0.021	0.441	0.118	0.083	0.925
SEM	24.57	0.03	15.22	18.37	4.41

[a,b]Means within the same row with different letters are significantly different by F test ($P < 0.05$).

According to Maiorka et al. (2016), taller villi indicates greater area for digestion and absorption, whereas deeper crypts indicates greater turnover of enterocytes. Furthermore, the intestinal mucosa plays an essential role in the digestion and absorption of nutrients via enterocytes. Thus, the results of the present study indicate that the intestinal mucosa of embryos and chicks from old breeders (51 wk) was more mature at hatching than for young breeders (38 wk), which could contribute to better performance and better adaptation to exogenous feeding. Likewise, Cardeal et al. (2020) stated that the use of a prehousing diet is recommended for chicks breeders submitted to a long period of fasting because it stimulates growth of the small intestine until 14 d of age.

Hatchability for the slow-growing breeder eggs in this study was relatively low compared with indexes founds in the literature for hatchability of eggs from fast-growing breeding stock, which reach rates greater than 90.0% (Araújo et al., 2019). The hatchability of eggs and the reproductive characteristics of roosters and hens are characteristics that have been improved by intensive breeding programs with the main commercial broiler strains. The relatively low hatchability for eggs from slow-growing breeders, however, may still have been reduced by the use of recommended incubation standards for fast-growing strains. The hatch window, which technically influences chick quality in the expedition to farms, was greater for birds from fast-growing breeding stock. According Willemsen et al. (2008), chicks that hatch at the beginning or end of the hatch window have lower growth potential. However, in the present study, despite the difference observed in the hatch window, chick quality was not affected by hen age, with most chicks having a quality score greater than 90 points.

Chick hatching time and breeder age were able to influence chick performance, either individually or interacting together. In the first week, chicks born earlier and from younger hens had lower BW in the first week. Yolk-free weight at removal was higher for old breeders (35.79 g) than that of young breeders (33.14 g), which certainly influenced BW in the first week. In addition, there was less feed consumption for chicks from young breeders, which may have also contributed to maintaining lower BW compared with chicks from old breeders. Likewise, studying the effects of the age of Ross sires (30, 48, and 60 wk), Muerer et al. (2008) also found lower feed intake and less weight gain for chicks from younger than older breeders (60 and 48 wk).

Time for hatching did not influence individual consumption of feed, feed conversion, or weight gain at

Table 9. Interaction between breeders age and hatching time on body chick weight at 7 d.

	Hatching time	
Breeders age (wk)	479–485 h	491–497 h
38	101.0[B,b]	112.7[A,a]
51	113.1[A,a]	113.5[A,a]

Means within the same column [A,B] and row [a,b] with different letters are significantly different by F test ($P < 0.05$).

Table 10. Interaction between breeders age and hatching time on feed intake at 14 d.

	Hatching time	
Breeders age (wk)	479–485 h	491–497 h
38	$334.7^{B,b}$	$360.2^{A,a}$
51	$361.7^{A,a}$	$357.4^{A,a}$

Means within the same column ^{A,B} and row ^{a,b} with different letters are significantly different by F test ($P < 0.05$).

7 d. These results corroborate those of the study by Almeida et al. (2008), who found that Ross-strain broiler chicks that hatched at different times, yet were removed from the machines at the same time, had similar weight gain.

The results of the present study disagree with those of the study by El Sabry et al. (2013), who evaluated the effects of age of Ross sire breeders and hatching time on chick performance and observed an interaction between the factors such that those from older breeders hatched in a late period (494 h) had less feed conversion at 7 d. Such differences between the literature and the results of the present study may be explained by the fact that genetic improvement of industrial broilers prioritized strains for greater weight gain in less time and better feed conversion. For currently used commercial strains, broiler BW increases by about a factor of four in 7 d (Araújo et al., 2019). On the other hand, the BW of Isa Label Naked Neck chicks increases by only a factor of 2 in 7 d.

In the present study, chicks from young breeders (smaller eggs) were born first and were lighter and remained longer in the setter, leading to greater dehydration (Araújo et al., 2016). Therefore, they were unable to regain weight by 7 d and remained underweight compared with other treatments. Thus, the results of the present study suggest a new hatchery management proposal involving the early withdrawal of chicks from younger breeders that hatched in an early period to reduce damage to quality and initial performance of chicks. Performance at 21 d maintained the effect of breeder age in which chicks from older breeders showed greater weight gain and final weight than chicks from younger breeders, despite having the same feed intake.

The effect of chick hatch time was observed in the stages of 21 and 28 d of rearing. Chicks born later had higher BW, regardless of breeder age. These results show that the effects of incubation time can be more harmful than the effects of slow-growing breeder age during the rearing phase up to 28 d. In accordance with the norms for standardization of free-range chickens (ABNT, 2015), after 28 d, chicks need to have access to paddocks, which makes it difficult to evaluate performance owing to the lack of control over chicken feed in the external environment, and thus, the present experiment ended at 28 d of rearing.

CONCLUSION

Embryos from older breeders have greater weight and greater intestinal development. These results positively influence the performance of broilers up to 21 d. The incubation of eggs from slow-growing breeders needs to be studied because, in spite of good fertility of the flock,

Table 11. Effect of breeders age and hatching time on growth performance of slow-growing broiler chicks.

	1 to 21 d of age				
Items	Feed intake (g)	Feed convertion ratio (g/g)	BW gain (g)	BW (g)	Viability (%)
Breeders age (wk)					
38	774.6	1.800	432.4^{b}	470.9^{b}	96.1
51	782.9	1.761	444.7^{a}	484.3^{a}	97.4
Hatching time					
479–485 h	773.4	1.790	433.9^{b}	471.9^{b}	96.5
491–497 h	784.0	1.771	443.1^{a}	483.2^{a}	97.0
P-value					
Breeders age	0.524	0.291	0.012	0.007	0.355
Hatching time	0.418	0.691	0.056	0.022	0.844
Age x hatching time	0.908	0.384	0.216	0.140	4.33
SEM	44.54	0.07	42.87	22.65	3.39
	1 to 28 d of age				
Items	Feed intake (g)	Feed convertion ratio (g/g)	BW gain (g)	BW (g)	Viability (%)
Breeders age (wk)					
38	1.366.1	1.963	696.0	734.5	94.8
51	1.372.3	1.926	712.1	751.6	97.4
Hatching time					
479–485 h	1.350.5	1.954	691.1^{b}	728.8^{b}	96.5
491–497 h	1.387.8	1.934	716.9^{a}	757.1^{a}	95.7
P-value					
Breeders age	0.819	1.134	0.123	0.103	0.129
Haching time	0.182	0.411	0.016	0.009	0.577
Age x hatching time	0.753	0.974	0.683	0.630	0.454
SEM	55.42	0.04	56.91	33.71	3.94

^{a,b}Means within the same row with different letters are significantly different by F test ($P < 0.05$).

hatching rates were low because the setter was regulated based on patterns for fast-growing strains. In addition, chicks from younger hens that hatch earlier (479–485 h in the present study) are of poorer quality.

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DISCLOSURES

The authors declare no conflicts of interest.

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