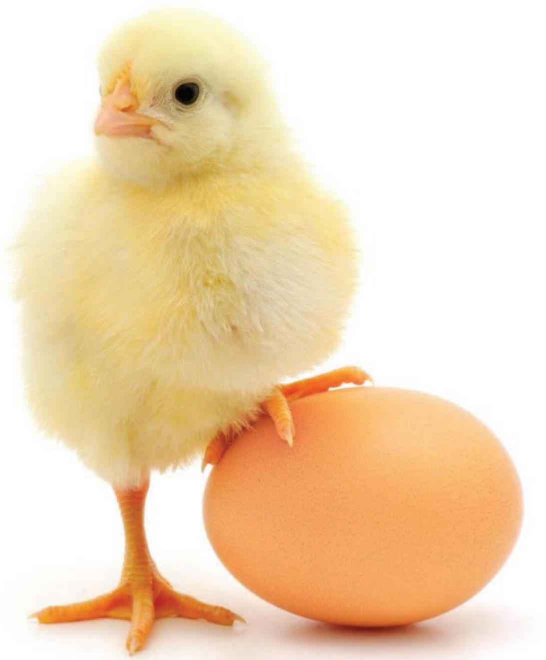
ISSN 1682-8356
ansinet.com/ijps



INTERNATIONAL JOURNAL OF POULTRY SCIENCE

Science Alert
scialert.net

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2023.46.57

Research Article
Effect of Induced Molting on Production Performance, Egg Quality, Hatching Traits and Juvenile Performance of Sasso Broiler Breeders

[1]Atoo Ashir Foreman, [1,2]Nideou Dassidi, [1]N'nanlé Oumbortime, [3]Okanlawon Onagbessan and [1]Kokou Tona

[1]Laboratory of Poultry Sciences, Regional of Excellence Centre on Poultry Science, University of Lomé, B.P. 1515 Lomé, Togo
[2]Département des Sciences et Techniques d'Elevage, Institut National Supérieur des Sciences et Techniques d'Abéché, BP : 6077 Abéché, Tchad
[3]Department of Animal Physiology, Federal University of Agriculture, Abeokuta, Nigeria

Abstract
Background and Objective: Moulting of older breeders is a procedure to obtain or to increase reproductive performance of breeders by restoration of egg quality. A 15-week study was carried out to examine the effect of induced molting of Sasso broiler breeders by feed withdrawal for a period of 9 days on the production performance, egg quality, hatching traits and 1-week post-hatch chick performance. **Materials and Methods:** A total of 240 Sasso broiler breeders (72 weeks old) were randomly allotted to two treatment groups (non-molt and molt) of 120 hens each. Each group was further divided into six replicates with 20 hens per replicate and 2 cocks each. The hens in the molt treatment group were subjected to molting by feed withdrawal for a period of 9 days. After the commencement of egg production, eggs were collected from the two experimental groups and incubated (from the 7th week after molting). Collection and incubation were repeated 5 times. The chicks hatched from these incubations were reared for 1-week. **Results:** The eggs from the molted hens had a higher albumen height and haugh unit. The eggs from the molted hens had an improvement in fertility while the hatchability of the fertile eggs was not different in the 2 groups. The incubation duration, chick weight and quality at hatch showed no difference between the treatments. At the end of the 7 days post-hatch, there was no difference in chick performance. **Conclusion:** It was concluded that although induced molting procedure with feed withdrawal improved the production, quality and fertility of eggs of Sasso broiler breeders, it did not influence chick quality and 1-week performance.

Key words: Broiler breeders, chick performance, egg quality, fertility and induced molting

Citation: Foreman, A.A., N. Dassidi, N. Oumbortime, O. Onagbessan and K. Tona, 2023. Effect of induced molting on production performance, egg quality, hatching traits and juvenile performance of sasso broiler breeders. Int. J. Poult. Sci., 22: 46-57.

Corresponding Author: Atoo Ashir Foreman, Laboratory of Poultry Sciences, Regional of Excellence Centre on Poultry Science, University of Lomé, B.P. 1515 Lomé, Togo Tel: (+235) 66 29 05 45

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The age of breeders influences the number of eggs and egg quality[1]. Also, fertility, embryonic mortality and hatchability rates depend on the age of the breeder flock[2-5]. The production of eggs in laying flocks, fertility, hatchability of set eggs and hatchability of fertile eggs are limited by age and decrease with the increase in the breeder age[6,7]. The hatching egg weight and the weight of day-old chick at hatch are also dependent on the breeder age[8]. The chick quality is lower in chicks hatched from eggs from older breeders[9,10]. As shown by Tona, *et al.*[11], the effect of age could be reversed by molting the breeders, to improve performance.

Induced molting is a management tool used to rejuvenate the reproductive system of egg-laying hens at the end of the laying cycle, which averagely ranges from 70-85 weeks in commercial layers and 60-65 weeks in breeders[12]. Generally, it is known that molting may be induced by feed and water withdrawal[13], by variable nutrient diets or by diets high in minerals[14], or by injection of hormones[1]. The most widely practiced method to induce a molt is feed withdrawal and a restriction of the photoperiod to the natural day length or less and occasionally restriction of drinking water[15].

With induced molting a significant loss of weight, changes in the histo-physiology of the reproductive system, which in turn leads to interruption in egg production for a short period, subsequent improvement in egg quality and an increased post-molt egg production was observed[16]. It also affects fertility[17], hatchability[11] and chick quality. Generally, different strains of birds may respond differently to induced molting[18]. To our knowledge, there is scarcity of study on the response of Sasso broiler breeders to induced molting in the tropical environments. Thus, this study was carried out to evaluate the effect of induced molting on production performance, reproductive tract morphometry, egg quality, fertility, hatching traits, chick quality and the 1-week post-hatch performance of chicks after induced molting of Sasso broiler breeders using the feed withdrawal method.

MATERIALS AND METHODS

Experimental design: Two hundred and forty (240) 72 weeks old Sasso broiler breeder hens were used for this study. The birds were weighed and randomly allotted to 2 groups (non-molt and molt) of one hundred and twenty (120) hens each using a completely randomized design. Each group was further divided into six replicates with 20 hens per replicate. Each replicate was housed together with two cocks. Molting was done by a short-term feed withdrawal technique. Feed withdrawal with water provided *ad-libitum* lasted for 9 days. During the first 6 days of the feed withdrawal period, the hens were offered 10 g hen^{-1} day^{-1} of oyster shell. During molting, hens were fasted of feed until they lost 17.35% of their initial weight and then feeding was recommenced on the 10th day with pullet diet by gradual refeeding of hens with 30 g bird^{-1} day^{-1} up to 118 g bird^{-1} day^{-1}. At 5% of egg production, the birds were offered the normal breeder diet until the end of the experiment (i.e., experimental week 14). During the feed withdrawal phase the lighting program was 12L: 12D and in the post-molt phase the lighting program was 16L: 8D. From day 1 of the experiment, the non-molted birds were continuously fed the normal breeder diet. Eggs and required data were collected daily. Samples of eggs were used for egg quality measurements at different times. After molting and the recommencement of full egg production, [from the 7th week after molting i.e., at 81, 82, 84, 85 and 86 weeks of age of the breeders (AOB)], the total settable eggs in all the replicates of the molted and the non-molted hens were collected and incubated every week (i.e., total of 5 incubations). Each batch of the hatched chicks were reared for a period of seven days to ascertain the 1-week post-hatch juvenile chick performance.

Management of Sasso broiler breeder: The birds were weighed daily and quantity of feed offered and the leftover was weighed and recorded weekly. Weekly feed intake was determined as the difference between the quantity of feed offered and the quantity of feed leftover.

The experimental birds were weighed at the beginning of the experiment and on weekly basis until the end of the experiment. During the molting period, the body weights of the molted birds were recorded 3 times in a week and the percentage weight loss was determined until they lost 17.35% of their initial weight. At this point of weight loss, feed withdrawal was stopped.

The daily egg production was recorded throughout the experiment and used to calculate the weekly egg production percent in each experimental group. The egg production was expressed as the laying rate and calculated using the following formula as described by Dikmen *et al.*[19]:

$$\text{Laying rate} = \frac{\text{Total number of eggs collect}}{\text{No. of hens}} \times 100$$

From the weekly feed intake, the number of egg eggs laid and average egg weight, the feed conversion ratio (FCR) was calculated. FCR was calculated as cited by Anene *et al.*[20]:

$$\text{FCR} = \frac{\text{Total feed intake (g)}}{\text{Egg mass (g)}}$$

The egg mass is the average egg weight multiplied by the total number of eggs for that week.

Daily mortality was recorded and at the end of the experiment, mortality was calculated as the ratio of the number of dead birds to the number of birds per treatment, expressed as a percentage.

$$\text{Mortality (\%)} = \frac{\text{No. of dead birds}}{\text{Total No. of birds stocked}} \times 100$$

Gross morphometry of the reproductive tract: The gross morphometry of the oviduct and the ovary was assessed. This was done at the end of the feed withdrawal period (0% egg production) just before recommencement of feeding and at 40% lay (5 weeks after the end of the feed withdrawal period). Two hens were randomly selected per replicate to examine the oviduct. The hens were sacrificed by cervical dislocation and then cut open along the rib cage to expose the organs in the abdominal cavity and all the reproductive tract was removed. The length and weight of the different sections of the oviduct (infundibulum, magnum, isthmus, uterus and vagina) were measured.

Egg quality: The internal and external egg quality was assessed 6 times during the experiment. Five freshly laid eggs were collected per replicate (i.e., 30 per treatment, from the 5th week after molting at experimental week 7, 9, 10, 12, 13 and 14) and used to assess egg quality parameters. The freshly laid eggs were collected before 11:00 am on the days of egg quality assessment. The egg quality parameters were determined using a semi computerized system 'Bröring' software (Futura 2A 2011, manufactured by Bröring Technology GmbH, Niedersachsen, Germany); the egg weight, albumen height and Haugh unit were automatically recorded by this software. The external egg quality parameters assessed were the egg weight, egg length and diameter, shell weight, shell thickness while the internal egg quality parameters assessed were albumen height, albumen Haugh unit, yolk color yolk and albumen weight. The proportions of shell, yolk and albumen were also calculated as described by Dikmen *et al.*[21]:

$$\text{Yolk proportion} = \frac{\text{Yolk weight (g)}}{\text{Egg weight (g)}} \times 100$$

$$\text{Albumen proportion} = \frac{\text{Albumen weight (g)}}{\text{Egg weight (g)}} \times 100$$

$$\text{Shell proportion} = \frac{\text{Shell weight (g)}}{\text{Egg weight (g)}} \times 100$$

Incubation: For incubation, the settable eggs were numbered, weighed individually and set in single stage incubators (Pas Reform) at the temperature of 37.5°C (later reduced to 36.5°C after the 18th day), humidity of 60% and automatic egg turning (eggs rotate through 90°) set hourly. On the 18th day of incubation, eggs were candled and the fertile eggs were transferred from the turning trays to the hatching baskets in the hatcher.

Fertility was calculated as the number of fertile eggs divided by the total number of eggs set multiplied by 100. The fertile eggs were determined by candling on day 18 of incubation. The hatchability percentage was determined by dividing the number of hatched eggs per replicate by the total number of fertile eggs in each replicate and then multiplying by one hundred.

$$\text{Fertility rate (\%)}^{22} = \frac{\text{No. of fertile eggs}}{\text{No. of egg incubated}} \times 100$$

$$\text{Hatchability of fertile (\%)}^{22} = \frac{\text{No. of chicks hatched}}{\text{No. of fertile eggs}} \times 100$$

The hatching times were recorded to ascertain the duration of incubation. The duration of incubation was determined as the average time of hatch.

Chick quality: At the end of each incubation period at hatch, the average weights of hatched chicks in the two treatment groups were recorded and then the quality of the hatched chicks was assessed immediately after hatch using Tona score[23].

One-week post-hatch performance of chicks: The initial body weight of the chicks was recorded and the chicks were reared under normal brooding conditions and fed a broiler starter diet (2,926 kcal kg^{-1}, 21% crude protein). The quantity of feed consumed was recorded and the final body weight at the end of 7 days was measured. The juvenile growth performance of the chicks was evaluated for the first week after hatch in terms of the final body weight and relative growth as described by Tona *et al.*[10]:

$$\text{Relative growth} = \frac{\text{Average of first week post hatch weight gain}}{\text{Initial average weight at day 1}} \times 100$$

Statistical analysis: The software Graph Pad Prism 8.0.2 was used for data analysis. The student t-test was used to compare the sample means. The generalized linear regression model was used to analyze the effects of molting on egg production, egg weights and egg components, feed intake, feed ratio conversion, duration of incubation and post hatch weights. Differences of $p<0.05$ were considered statistically significant. When the means of the general model were statistically different, then the means were further compared using Tukey's test. In a second analysis, hatchability was considered as binomial distribution. A 2-tailed test for comparison of variances was used to analyze the effect of molting on hatchability.

RESULTS

Weekly body weight and feed intake: Figure 1a shows that molting significantly ($p<0.05$) influenced the average weekly weight of the hens throughout the course of this experiment. There was a drop in weight of the molted hens at the commencement of feed deprivation and the subsequent regain of the weight after the recommencement of feeding. The molted hens attained 17.35% weight loss on the 9th day of the experiment. Molting significantly ($p<0.05$) influenced the average daily feed intake of the hens throughout the experimental duration. The overall feed consumption of the molted hens was lower than those of the non-molted (control) hens (Fig. 2a).

Weekly laying rate: Generally, molting significantly ($p<0.05$) influenced the laying rate. The egg production was higher in molted hens after recommencement of laying (Fig. 3a). Cessation of lay in the molted hens was observed averagely on the 6th day of feed withdrawal. Recommencement of lay was averagely on the 23rd day (week 3 of the experiment) of the experiment i.e., 2 weeks after the FW period. Molted hens reached a peak of lay (60.24%) at week 9 and 10 of the experiment while the highest laying rate (47.73%) was recorded in the non-molted hens during the entire duration of the study. The laying rate was significantly ($p<0.05$) higher in molted hens from the 7th week of the experiment until the end of the experiment.

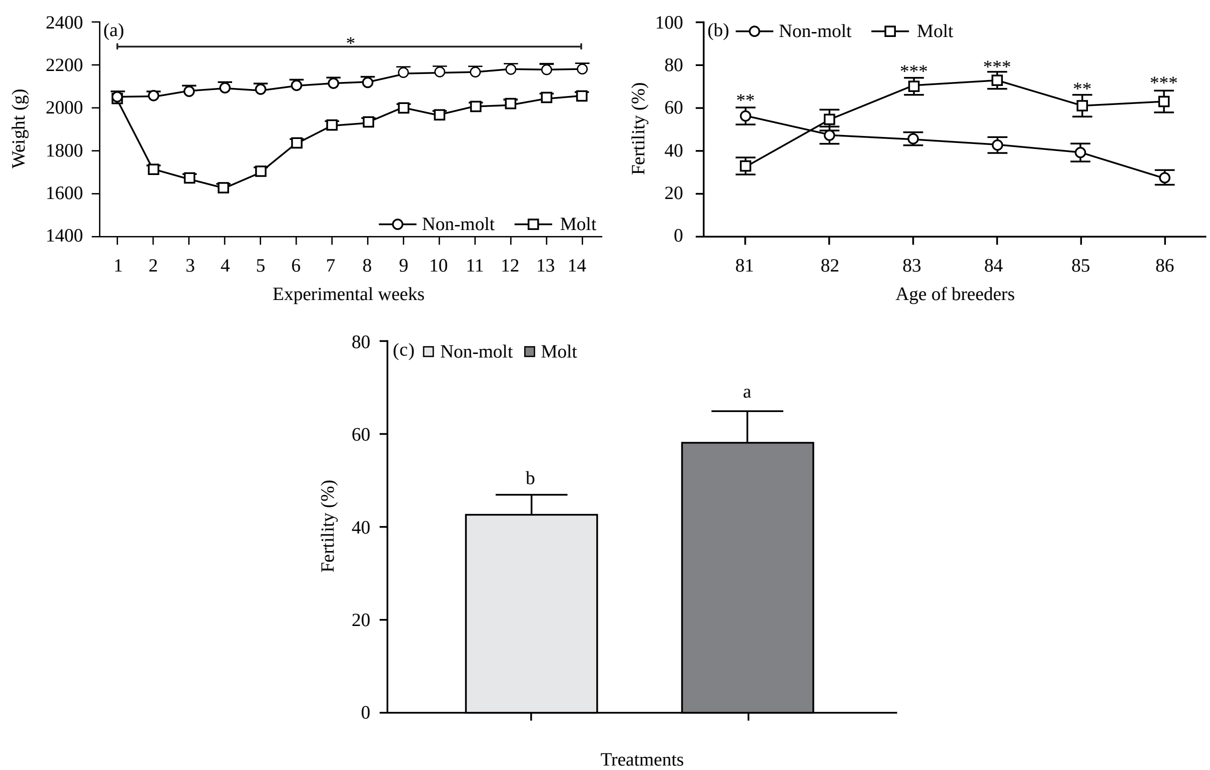


Fig. 1(a-c): (a) Average body weight of the non-molted and the molted hens from the beginning to the end of the study, (b) Effect of molting on fertility from 81-86 weeks AOB and (c) Overall effect of molting on fertility

*Indicates the differences between non-molted and molted hens ($p<0.05$)

Table 1: The overall production performance of the non-molt and the molt hens

	Treatments		
Parameters	Non-Molt	Molt	p-value
Daily feed intake (g)	135.70 ± 1.62^{a}	116.50 ± 0.46^{b}	<0.0001
FCR	5.61 ± 0.21^{a}	4.10 ± 0.39^{b}	0.0053
Laying rate	41.50 ± 1.51^{b}	51.96 ± 2.19^{a}	0.0015
Egg weight (g)	59.57±0.45	58.77±0.67	0.331
Mortality (%)	5.83±2.71	3.33±1.67	0.4506

^{a,b}Means±SEM (standard error of mean) within row values with different superscript differ significantly (p < 0.05), Daily feed intake, laying rate and FCR were from 7-14 weeks

Table 2: Gross morphometry of the ovary and oviduct at the end of feed withdrawal and 5 weeks after feed withdrawal (at 40% lay)

	Treatments					
	At the end of feed withdrawal			AT 40% LAY (5 weeks after FW)		
Parameters	Non-molt	Molt	p-value	Non-molt	Molt	p-value
Number of yellow follicles	5.00 ± 0.45^{a}	0.50 ± 0.34^{b}	<0.0001	5.17±0.79	4.83±0.6	0.7444
Yellow follicles weight (g)	30.50 ± 2.36^{a}	1.50 ± 1.03^{b}	<0.0001	42.59±9.12	35.95±5.66	0.5499
Oviduct length (cm)	76.03 ± 3.08^{a}	54.95 ± 3.11^{b}	0.0007	64.88±0.78	69.52±2.19	0.0738
Oviduct weight (g)	62.28 ± 5.81^{a}	20.08 ± 2.34^{b}	<0.0001	51.77±5.30	51.55±4.99	0.9767
Infundibulum length (cm)	9.20 ± 0.60^{a}	7.47 ± 0.36^{b}	0.0326	8.55±0.55	8.93±0.52	0.6229
Infundibulum weight (g)	2.40 ± 0.27^{a}	1.15 ± 0.23^{b}	0.0052	1.99±0.22	2.04±0.23	0.8718
Magnum length (cm)	37.50 ± 1.82^{a}	25.63 ± 2.48^{b}	0.0032	30.00±0.72	32.07±1.36	0.2086
Magnum weight (g)	32.33 ± 3.59^{a}	7.83 ± 1.74^{b}	0.0001	24.80±3.00	26.52±3.92	0.7351
Isthmus length (cm)	10.25 ± 0.48^{a}	8.22 ± 0.42^{b}	0.0098	9.48±0.51	10.65±0.44	0.1143
Isthmus weight (g)	5.18 ± 0.85^{a}	1.87 ± 0.16^{b}	0.0032	4.90±0.38	4.88±0.39	0.9640
Uterus length (cm)	10.05 ± 0.75^{a}	8.2 ± 0.40^{b}	0.0533	10.07±0.47	10.67±0.68	0.4873
Uterus weight (g)	17.50 ± 2.20^{a}	7.67 ± 0.56^{b}	0.0015	16.71±2.06	14.87±0.87	0.4289
Vagina length (cm)	9.03 ± 0.37^{a}	5.43 ± 0.56^{b}	0.0003	6.78±0.29	7.20±0.25	0.3015
Vagina weight (g)	1.72 ± 0.10^{a}	1.02 ± 0.06^{b}	0.0001	3.37±0.49	3.25±0.48	0.8703

^{a,b}Means±SEM (standard error of mean within row values with different superscript differ significantly (p<0.05)

Overall production performance: Table 1 shows that feed intake and feed conversion ratio (FCR) were lower (p<0.05) in molted hens compared to the non-molt group while egg production was higher in the molted hens. However, there were no significant differences (p>0.05) in the average egg weight and the mortality among the two treatment groups.

Ovary and Oviduct morphometry: Table 2 show that the number of yellow follicles, weight of yellow follicles, the length and weight of the oviduct and its segments at the end of feed withdrawal period were significantly higher (p<0.05) in the non-molted hens when compared to the molted hens. Nevertheless, with regard to the same parameters, there were no significant differences (p>0.05) across the two treatment groups after 5 weeks of the feed withdrawal period.

Egg internal and external quality: Table 3 shows that egg weight, egg height, egg width, shell weight, shell thickness, yolk weight, albumen weight, shell proportion, yolk proportion, albumen proportion and yolk color were not significantly (p>0.05) affected by molting while the albumen height and the albumen Haugh unit were significantly (p<0.05) affected by molting. The eggs from the molted hens had a significantly higher albumen height and Haugh unit when compared to the control.

Fertility and hatchability: Figure 1b shows the fertility of eggs from the molted group compared to the control group at 81, 83, 84, 85 and 86 weeks. Figure 1c shows that molting significantly influenced the overall fertility of eggs. The molted group had a significantly (p<0.05) higher average fertility (59.17±5.83) when compared to the non-molted group (43.24±3.86). Figure 2b shows the hatchability of fertile eggs from the molted group compared to the control group at 81, 83, 84, 85 and 86 weeks. Figure 2c shows that molting had no significant (p>0.05) effect on the hatchability of fertile eggs.

Incubation duration: Figure 3b shows that molting did not significantly (p>0.05) influence the average duration of incubation from 81 to 86 weeks of age of breeders. The overall effect of molting on average duration of incubation in the two groups is shown in Fig. 3c. There was no significant (p>0.05) difference in the average duration of incubation between the non-molted and the molted group.

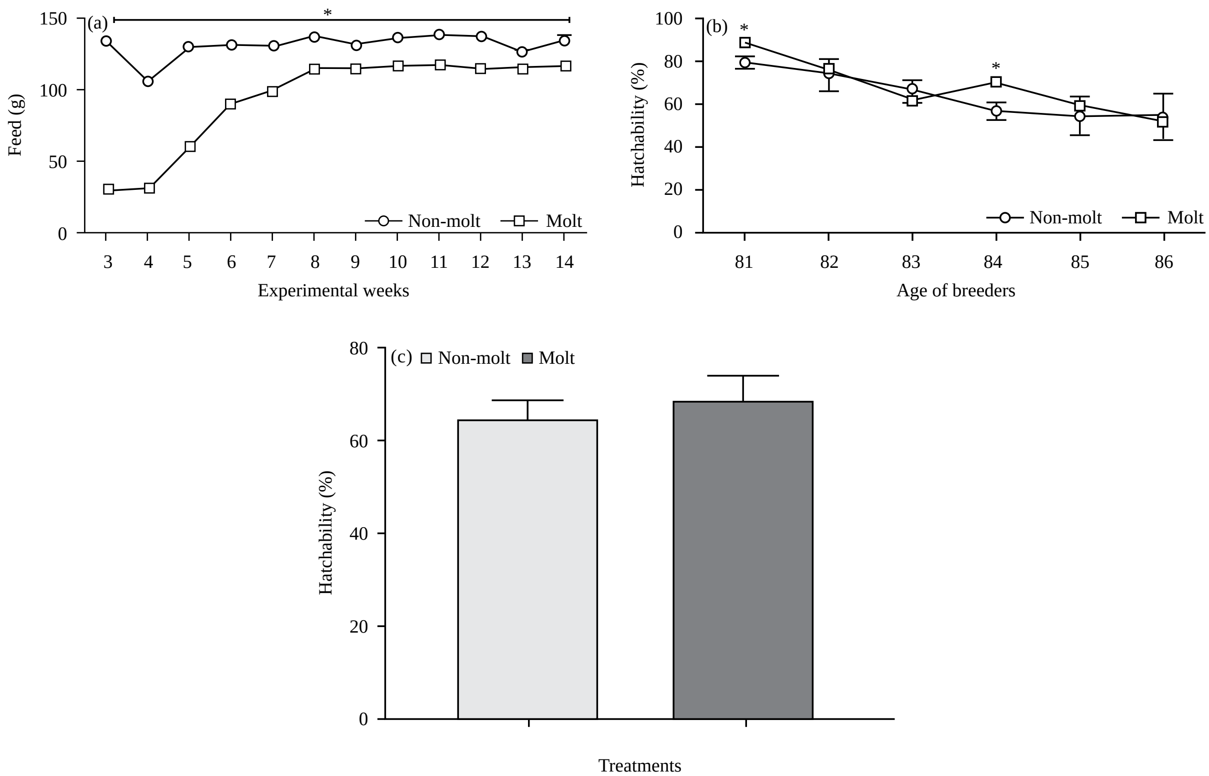


Fig. 2(a-c): Average daily feed intake of the non-molted and the molted hens after the recommencement of feeding of the molted hens until the end of the study, (b) Effect of molting on hatchability of eggs from 81-86 weeks AOB and (c) Overall effect of molting on hatchability of fertile eggs

*Indicates the differences between non-molted and molted hens ($p<0.05$)

Table 3: Egg internal and external quality parameters of eggs from the non-molted and molted hens

	Treatments		
Parameters	Non-molt	Molt	p-value
Egg weight (g)	59.03±0.81	58.91±0.75	0.9145
Egg height (mm)	58.22±0.39	57.30±0.29	0.0895
Egg width (mm)	42.64±0.23	43.19±0.25	0.1404
Shell weight (g)	7.08±0.15	7.20±0.09	0.5054
Shell thickness (mm)	0.29±0.004	0.31±0.004	0.0738
Yolk weight (g)	16.22±0.25	15.50±0.24	0.0652
Albumen weight (g)	34.95±0.55	35.53±0.46	0.4351
Albumen height (mm)	6.18±0.23^{b}	7.90±0.35^{a}	0.0022
Haugh Unit	76.18±1.90^{b}	87.99±2.25^{a}	0.0025
Shell proportion (%)	12.19±0.25	12.51±0.15	0.3052
Yolk proportion (%)	27.88±0.22	26.93±0.37	0.0522
Albumen proportion (%)	59.93±0.41	60.93±0.18	0.0523
Yolk colour	3.49±0.17	3.62±0.16	0.5745

^{a,b}Means±SEM (standard error of mean) within row values with different superscript differ significantly ($p<0.05$)

Chick weight at hatch and chick quality: Figure 4a shows the average chick weight from the molted group compared to the control group at 81, 83, 84, 85 and 86 weeks AOB. Figure 4b shows that there was no significant ($p>0.05$) difference in the chick weight at hatch between the non-molted and the molted group. Molting did not significantly ($p>0.05$) influence the average quality score of chicks at hatch from 81-86 weeks of AOB (Fig. 5a). The overall effect of molting on the average chick quality scores in the two groups is shown in Fig. 5b. Chick quality scores were not different ($p>0.05$) as seen in the non-molted and the molted group.

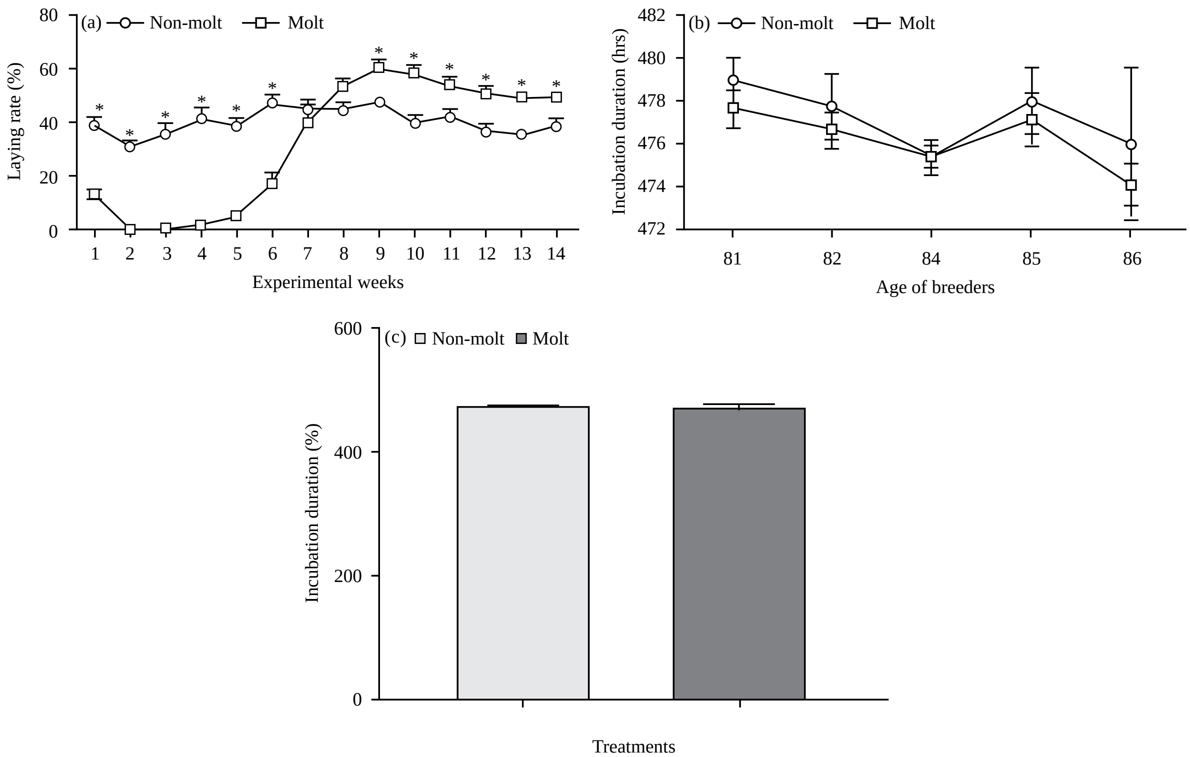


Fig. 3(a-c): Average laying rate of the non-molted and molted hens from the start of the experiment to the end showing the initial drop in egg production, cessation and subsequent recommencement of lay in the molted hens, (b) Average incubation duration of eggs from 81-86 weeks AOB from the non-molted and molted and (c) Overall effect of molting on the average incubation duration

*Indicates the differences between non-molted and molted hens (p<0.05)

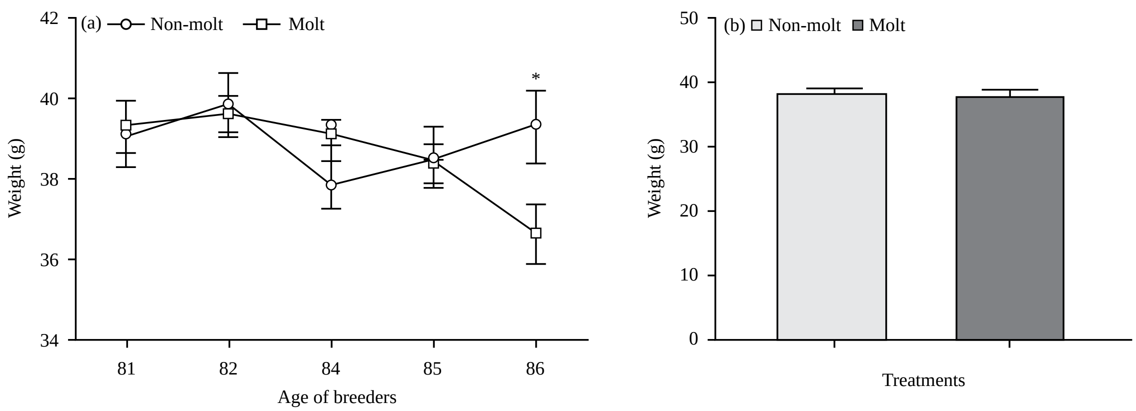


Fig. 4(a-b): Chick weight at hatch from 81 weeks to 86 weeks AOB from the non-molted and molted and (b) Overall effect of molting on Chick weight at hatch

*Indicates the differences between non-molted and molted hens (p<0.05)

One-week post-hatch chick performance: The average chick weight at 1-week post-hatch from the molted group compared to the control group at 81, 83, 84, 85 and 86 weeks of AOB is shown in Fig. 6a. There was no significant (p>0.05)

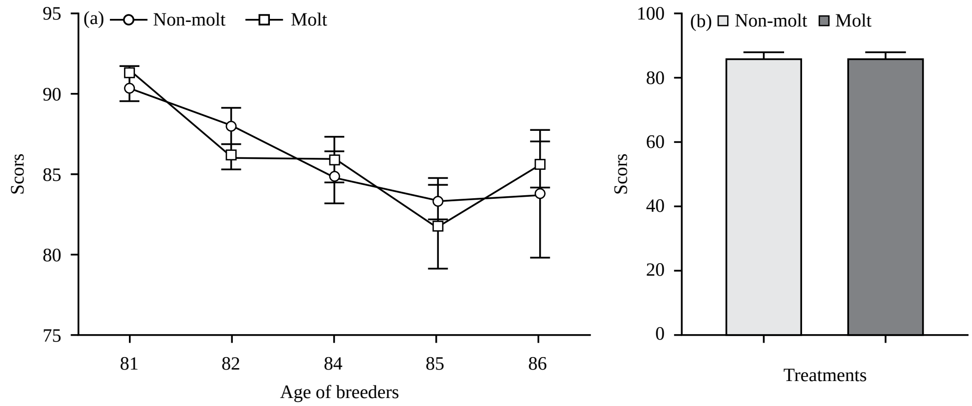


Fig. 5(a-b): Average score of all chicks from 81-86 weeks AOB from the non-molted and molted and (b) Overall effect of molting on average score of all chicks
*Indicates the differences between non-molted and molted hens (p<0.05)

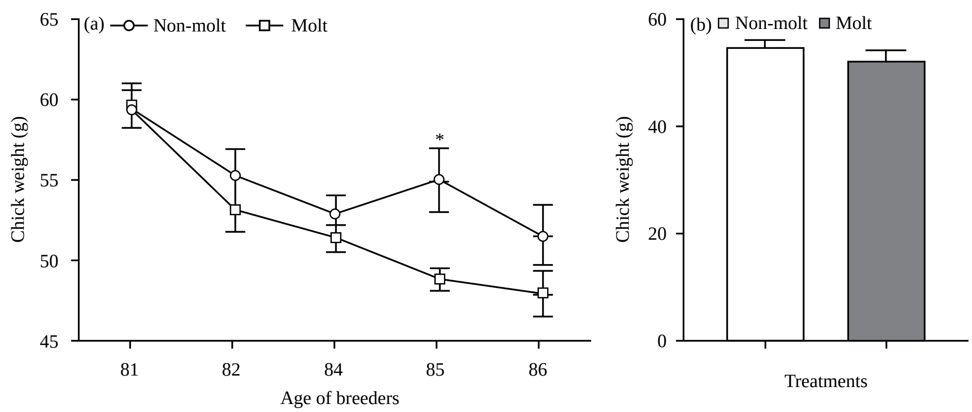


Fig. 6(a-b): (a) Chick weight at 1-week post-hatch from 81-86 weeks AOB from the non-molted and molted and (b) Overall effect of molting on chick weight at day 7
*Indicates the differences between non-molted and molted hens (p<0.05)

difference in the 1-week post-hatch average chick weight between the non-molted and the molted group (Fig. 6b). Fig. 7a shows the relative growth at 1-week post-hatch of chicks at 81, 83, 84, 85 and 86 weeks of AOB. Figure 7b shows that molting did not significantly (p>0.05) influence the overall relative growth of chicks at 1-week post-hatch in the two experimental groups.

DISCUSSION

This study has proved that induced molting can improve the rejuvenating reproductive efficiency of old Sasso broiler breeders and it is also previously reported in other strains of chickens . The average feed intake of molted hens after the molting period was lower than those of the non-molted hens. This observation is in line with the findings of Reddy *et al.*[24] who reported that after molting by feed withdrawal, hens consumed less feed with a better egg production when compared to the non-molted hens. The results showed that the feed conversion ratio was better in the molted hens than that of the control. This indicates that after molting, the molted hens were more efficient in utilizing the feed, meaning that the molted hens consumed significantly less feed and produced more eggs. The values of FCR in the molted hens and control were similar to those obtained by Hassanien[25] and Reddy *et al.*[24] who used Bovan layers aged 72 weeks to molt for 10 days. These results fulfill the purpose of molting regarding feed efficiency. McDaniel[26] stated that induced

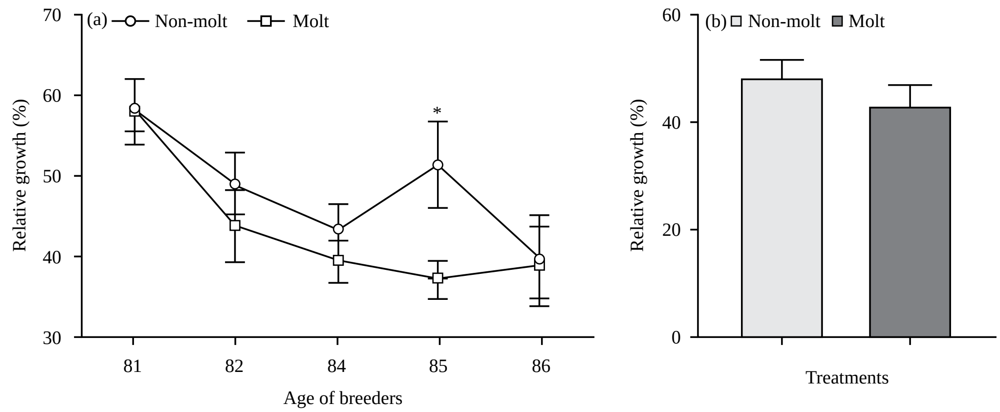


Fig. 7(a-b): (a) Relative growth 1-week post-hatch from 81-86 weeks AOB from the non-molted and molted and (b) Overall effect of molting on the week one relative growth of chicks

*Indicates the differences between non-molted and molted hens ($p<0.05$)

molting is usually adopted as a countermeasure where there is a high rate of feed and low rate of eggs (i.e., poor feed conversion ratio).

At the end of the 9 days FW, regression of the oviduct, ovary and the number of yellow follicles was observed in the present study. According to Brake *et al.*[27], the most important factor for induced molting is the regression of the ovary because it is the loss of weight of the reproductive organ that give rise to the whole rejuvenation process. According to Dickerman and Bahr[28], this severe weight loss of the reproductive tract may be due to the stress and reduced level of gonadotrophic hormones associated with induced molting. Five weeks after the FW period the reproductive tract was completely rejuvenated. This showed a rejuvenation in the reproductive tract, which had earlier regressed. According to Reddy *et al.*[24], this is due to the restart of the normal productive functional activity of the reproductive organs under the influence of gonadotrophic hormones.

A gradual decrease in the laying rate (egg production) was due to the Feed withdrawal. Similar results were reported by Cunningham[29] who found that fasted breeder hens require 5-8 days to reach 0% laying rate. A similar opinion was also expressed by El-Deek and Al-Harthi[30] who observed complete cessation of egg production after 8 days of fasting. The recommencement of lay can be compared with the findings of El-Sagher *et al.*[31] who reported the recommencement of lay at day 21 for a feed withdrawal period of 10 days. On the other hand, El-Deek and Al-Harthi[30] reported contrary results with 51 days feed withdrawal period. Egg production (laying late) gradually increased in the molted hens up to the 7th week of the experiment. After this, the laying rate of the molted hens was significantly higher than that of the control. This increase in egg production after molting agrees with Wu *et al.*[32]. This was probably due to increased tissue efficiency after the involution and rejuvenation of the reproductive system leading to the removal of fat accumulation. This result reinforces the results of a previous study conducted by Ahmad *et al.*[33] who reported that the peak of production of molted hens was significantly higher than those of the non-molted (control) hens. According to Hurwitz *et al.*[34]. induced molting increased egg production from 18.6-26.1% in White leghorn hens.

In the present study, a non-significant difference was observed in the average weight of eggs from the molted and the non-molted hens. This non-significant difference in egg weight can be attributed to the fact that after complete rejuvenation of the reproductive tract of the molted hens, there was no difference in the ovary and the oviduct segments between the molted hens and the control hens. Hence, egg formation was not affected in terms of egg weight. This result agrees with the finding of Ahmad *et al.*[33] and Hassanien[25] who also observed non-significant difference in egg weight of laying hens after molting. Induced molting generally has little or no influence on egg weight[35]. However, the result of the present study contradict with the findings of some authors[18,36] who indicated that egg weight increased after molting. Whereas, Tona *et al.*[11]. reported that the egg weight before molting was greater than the egg weight after molting. Mortality of hens was not significantly affected by molting as there was no significant difference in the mortality between the molted and the non-molted hens throughout this study. This shows that the loss of weight in the molted hens did not have any detrimental effect in terms of mortality. This result agrees with the findings of Webster[37] who reported no difference in mortality with induced molting.

The albumen height and Haugh unit which are the two most important internal egg quality parameters were significantly improved by molting. The values for these parameters were comparable with those of Reddy *et al.*[24], who reported albumen HU (74.84) in control hens and (86.48) in White Plymouth Rock breeder hens after molting. The increase in HU values after molting as seen in this present study is in correspondence with Attia *et al.*[1] and Tona *et al.*[11], who recorded an improved albumen quality in eggs from molted hens.

Fertility of the eggs from non-molted hens (control) followed a decreasing trend from 81-86 weeks of AOB which corroborates the fact that fertility decreases with age as has been reported in earlier studies[3,6,7,38,39]. Induced molting by FW in the present study significantly countered this effect of decreasing fertility with age as there was a relatively stable and significantly higher fertility from 83-86 weeks of AOB. The overall average fertility was significantly improved with this molting procedure throughout the duration of the incubation trial. This improvement in fertility may be due to the decrease in the abdominal fat of the hens as a result of the FW, for high abdominal fats in mature hens have been shown to have a negative impact on fertility[40]. This is in concurrence with results of Hall[17] who observed that molting through FW caused higher fertility in White Leghorn hens. However, this result is in disharmony with the findings of Reddy *et al.*[24], who observed no improvement in fertility when male and female broiler breeders were molted using several methods. Hatchability showed a decreasing trend with the age of the breeders for both treatment groups. This trend follows the known fact that hatchability decreases with the age of broiler breeders[7,38,39,41] which is primarily due to an increase in percentage of embryonic mortality[38]. Most likely due to the advanced age of the breeders used in the present study, molting could not cancel out this effect of decreasing hatchability with broiler age. Induced molting did not improve the overall hatchability of fertile eggs in the present study. In agreement with the current result Tona *et al.*[11] reported that the hatchability of eggs before and after molting was not significantly different when eggs were stored for less than 8 days. This result is consistent with a previous study conducted by Reddy *et al.*[24] who observed similar hatchability in the control and the induced molted hens. Despite of improving the egg quality and fertility, failure of molting to improve the hatchability of fertile eggs might be due to the higher embryonic mortality accompanied by other physiological reasons.

Chick quality decreases as the age of the breeder advances especially in old breeders. The current study showed this decreasing trend with the increasing age of the breeders. The effect of age of breeders on chick quality was not reversed with molting and this agrees with Tona *et al.*[11], who reported that the percentages of chicks of good quality were not different in offspring from molted and non-molted hens. It is well known that the day-old chick weight depends on the age of the breeders as well as the weight of the egg. In the present study, there was no significant difference in chick weight at hatch between the chicks from the molted and the non-molted (control) hens. This suggests that the molting procedure used in this study did not significantly affect the egg weight and therefore did not affect the day-old chick weight. This result is in correspondence with the report of Moran[42] who reported a linear relationship between the egg weight and the day-old chick weight. This also agrees with the findings of Tona *et al.*[11], who reported no difference in 1-day-old chick weight (at hatch) before and after molting of hens. Tona *et al.*[11] pointed out that it is not wise to predict the slaughter weight of chicks from the body weight at the end of incubation because the time of recording weights may affect the body weight of newly hatched chicks. Chick body weight between days 7-10 is linearly correlated with the weight at slaughter[37]. Against this background, the chicks were raised for a period of 7 days after hatch to determine the actual quality and vigor of the chicks. The 7-day-chick weight and the relative growth, which are the most important parameters for assessing the 1-week performance of the chicks raised from the eggs hatched, showed no significant improvement in their performance. This result contradicts with those of Tona *et al.*[11]. who reported that the chicks produced after molting showed higher weight at day 7. This discrepancy could be attributed to the difference in the genetic strain and differences in the ages of breeder hens used in both studies. Molting did not improve the 1-week post-hatch juvenile chick performance.

CONCLUSION

In conclusion, the study revealed that induced molting in Sasso broiler breeders through feed withdrawal for 9 days showed an involution of the oviduct and the ovary and complete rejuvenation of the oviduct and ovary after molting. Molting improved egg production, egg quality and the general performance of the breeders. Also, induced molting improved the fertility of eggs while the hatchability of fertile eggs was not improved with molting. Even though the hatchability of the eggs was not different, molting significantly increased the number of chicks subsequently hatched per

100 eggs incubated. Induced molting did not influence hatching traits, chick quality and the 1-week juvenile performance of chicks.

ACKNOWLEDGMENT

The authors are grateful to the World Bank through the Regional Center of Excellence in Poultry Science (CERSA), University of Lomé for providing the funding and facilities necessary for this study.

REFERENCES

1. Attia, Y.A., W.H. Burke and K.A. Yamani, 1994. Response of broiler breeder hens to forced molting by hormonal and dietary manipulations Poult. Sci., 73: 245-258.
2. Jassim, E.W., M. Grossman, W.J. Koops and R.A. Luykx, 1996. Multiphasic analysis of embryonic mortality in chickens. Poult. Sci., 75: 464-471.
3. Koppenol, A., E. Delezie, Y. Wang, L. Franssens and E. Willems *et al*., 2015. Effects of maternal dietary EPA and DHA supplementation and breeder age on embryonic and post-hatch performance of broiler offspring. Anim. Physiol. Anim. Nut., 99: 36-47.
4. Latour, M.A., E.D. Peebles, C.R. Boyle, S.M. Doyle, T.Pansky and J.D. Brake, 1996. Effects of breeder hen age and dietary fat on embryonic and neonatal broiler serum lipids and glucose. Poult. Sci., 75: 695-701.
5. O`Sullivan, N.P., E.A. Dunnington and P.B. Siegel, 1991. Relationships among age of dam, egg components, embryo lipid transfer and hatchability of broiler breeder eggs. Poult. Sci., 70: 2180-2185.
6. Almeida, J.G., S.L. Vieira, R.N. Reis, J. Berres, R. Barros, A.K. Ferreira and F.V.F. Furtado, 2008. Hatching distribution and embryo mortality of eggs laid by broiler breeders of different ages. Rev. Bras. Cienc. Avic., 10: 89-96.
7. Yilmaz-Dikmen, B. and U. Sahan, 2009. The relationship among age, yolk fatty acids content and incubation results of broiler breeders. Poult. Sci., 88: 185-190.
8. Decuypere, E. and V. Bruggeman, 2007. The endocrine interface of environmental and egg factors affecting chick quality. Poult. Sci., 86: 1037-1042.
9. Tona, K., F. Bamelis, W. Coucke, V. Bruggeman and E. Decuypere, 2001. Relationship between broiler breeder's age and egg weight loss and embryonic mortality during incubation in large-scale conditions. J. Applied Poult. Res., 10: 221-227.
10. Tona, K., O. Onagbesan, B. de Ketelaere, E. Decuypere and V. Bruggeman, 2004. Effects of age of broiler breeders and egg storage on egg quality, hatchability, chick quality, chick weight and chick posthatch growth to forty-two days. J. Appl. Poult. Res., 13: 10-18.
11. Tona, K., F. Bamelis, K.B. De Ketelaere, V. Bruggeman and E. Decuypere, 2002. Effect of induced molting on albumen quality, hatchability and chick body weight from broiler breeders. Poult. Sci., 81: 327-332.
12. Hemin, N.M. and A.A. Khasraw, 2019. The effect of environmental conditions and breeder age on egg quality characteristics. Applied Ecol. Environ. Res., 17: 12419-12439.
13. Oguike, M.A., G. Igboeli, S.N. Ibe and M. Uzoukwu, 2004. Effect of day length and feed/water regime on induction of feather moult and subsequent laying performance in the domestic fowl. Int. J. Poult. Sci., 3: 507-512.
14. Koelkebeck, K.W. and K.E. Anderson, 2007. Molting layers—alternative methods and their effectiveness. Poult. Sci., 86: 1260-1264.
15. Berry, W., 2003. The physiology of induced molting. Poult. Sci., 82: 971-980.
16. Jeong, W., W. Lim, S.E. Ahn, C.H. Lim and J.Y. Lee, 2013. Recrudescence mechanisms and gene expression profile of the reproductive tracts from chickens during the molting period. PLoS One, Vol. 10, 10.1371/journal.pone.0076784
17. Hall, G.O., 1946. The artificial control of egg production. Poult. Sci., 25: 3-12.
18. Bar, A., V. Razaphkovsky, E. Wax and Y. Malka, 2001. Effect of age at molting on postmolting performance. Poult. Sci., 80: 874-878.
19. Dikmen, B.Y., A. Ipek, U. Sahan, M. Petek and A. Sozcu, 2016. Egg production and welfare of laying hens kept in different housing systems (conventional, enriched cage and free range). Poult. Sci., 95: 1564-1572.
20. Anene, D.O., Y. Akter, P.C. Thomson, P. Groves and C.J. O'Shea, 2020. Variation and association of hen performance and egg quality traits in individual early-laying ISA brown hens. Animals, Vol. 10, 10.3390/ani10091601.
21. Dikmen, B.Y., A. İpek, Ü. Şahan, A. Sözcü and S.C. Baycan, 2017. Impact of different housing systems and age of layers on egg quality characteristics. Turk. J. Vet. Anim. Sci., 41: 77-84.
22. Mushonga, B., T. Benimana, E. Kandiwa, S. Chinyoka, A. Samkange, A.S. Bishi and G. Habarugira, 2017. Determination of fertility, hatchability and stage of embryonic death in non-hatching eggs at rubilizi national hatchery. Foc Sci 3: 1-6.
23. Tona, K., F. Bamelis, B.D. Ketelaere, V. Bruggeman and V.M.B. Moraes *et al*., 2003. Effects of egg storage time on spread of hatch, chick quality and chick juvenile growth. Poult. Sci., 82: 736-741.
24. Reddy, V., V.K. Malathi and B.S.V. Reddy, 2008. Effect of induced moulting in male and female line broiler breeder hens by zinc oxide and feed withdrawal methods on post molt performance parameters. Int. J. Poult. Sci., 7: 586-593.
25. Hassanien, H.H.M., 2011. Effect of force molting programs on egg production and quality of laying hens. Asian J. Poult. Sci., 5: 13-20.

26. McDaniel, B.A., D.R. Aske, 2000. Egg prices, feed costs and the decision to molt. Poult. Sci., 79: 1242-1245.
27. Brake, J., P. Thaxton, E.H. Benton, 1979. Physiological changes in caged layers during a forced molt Poult. Sci., 58: 1345-1350.
28. Dickerman, R.W., J.M. Bahr, 1989. Molt induced by gonadotropin-releasing hormone agonist as a model for studying endocrine mechanisms of molting in laying hens. Poult. Sci., 68: 1402-1408.
29. Cunningham, D.L., C.C. Mccormick, 1985. A multicycle comparison of dietary zinc and feed removal molting procedures: Production and income performance. Poult. Sci., 64: 253-260.
30. El-Deek, A.A. and M.A. Al-Harthi, 2004. Post molt performance parameters of broiler breeder hens associated with molt induced by feed restriction, high dietary zinc and fasting. Int. J. Poult. Sci., 3: 456-462.
31. Sagher, M.A., H. E. Hmmady, H. Hassanin and H. Hassan, 2014. Effect of fasting period and feed form on post molt performance and egg quality in laying hens. Egypt. Poult. Sci. J., 34: 619-634.
32. Wu, G., P. Gunawardana, M.M. Bryant, R.A. Voitle, D.A. Roland, 2007. Effect of molting method and dietary energy on postmolt performance, egg components, egg solid and egg quality in Bovans white and Dekalb white hens during second cycle phases two and three. Poult. Sci., 86: 869-876.
33. Ahmed, A.M.H., A.B. Rodriguez-Navarro, M.L. Vidal, J. Gautron, J.M. García-Ruiz and Y. Nys, 2005. Changes in eggshell mechanical properties, crystallographic texture and in matrix proteins induced by moult in hens. Br. Poult. Sci., 46: 268-279.
34. Hurwitz, S., E. Wax, Y. Nisenbaum, I. Plavnik, 1995. Responses of laying hens to forced molt procedures of variable length with or without light restriction. Poult. Sci., 74: 1745-1753.
35. Roland, D.A. and R.D. Bushong, 1978. The influence of force molting on the incidence of uncollectable eggs. Poult. Sci., 57: 22-26.
36. Ruszler, P.L., 1998. Health and husbandry considerations of induced molting. Poultry Science 77: 1789-1793.
37. Webster, A.B., 2000. Behavior of white leghorn laying hens after withdrawal of feed. Poult. Sci., 79: 192-200.
38. Elibol, O., S.D. Peak and J. Brake, 2002. Effect of flock age, length of egg storage and frequency of turning during storage on hatchability of broiler hatching eggs. Poult. Sci., 81: 945-950.
39. Zakaria, A.H., P.W. Plumstead, H. Romero-Sanchez, N. Leksrisompong, J. Osborne, J. Brake, 2005. Oviposition pattern, egg weight, fertility and hatchability of young and old broiler breeders. Poult. Sci., 84: 1505-1509.
40. Squires, E.J. and S. Leeson, 1998. Aetiology of fatty liver syndrome in laying hens. Br. Vet. J., 144: 602-609.
41. Lapao, C., L.T. Gama, M.C. Soares, 1999. Effects of broiler breeder age and length of egg storage on albumen characteristics and hatchability. Poult. Sci., 78: 640-645.
42. Moran, E.T., 1990. Effects of egg weight, glucose administration at hatch and delayed access to feed and water on the poult at 2 weeks of age. Poult. Sci., 69: 1718-1723.