International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Effects of Plumage Color Modifier Genes and Storage Duration on Eggs Qualities Traits of Japanese Quail (*Cortunix Japonica*) Reared In Subtropical Climate

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Abstract

The main objective of this research was to study the effect of storage duration on egg quality of two genotypes with different feather color (yellow and wild-type quails or brown). Research variables were the weight of eggs, interior and exterior quality of eggs. 780 eggs from two groups of 45 quails per genotype, collected and stored during 13 days, were used. The tests used in our study were the Student's t-test, the ANOVA and the post-ANOVA tests. The results carried out a significant difference among the different genotypes concerning the external eggs quality ($P<0.001$). The wild-type quails got the high average concerning the length, the width and conformation rate than yellow quails. Moreover, these quails recorded also high weight than the others. The same result was recorded for final weight average.

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The eggs of quails of wild-type feather showed out better mean such as 79.87 %, 31.55 mm and 25.16 mm for respectively conformation rate, the length and the width. Eggs weight was affected by quail feather color. Thus, the eggs of females with wild-type feathers carried out the high weight (10.75 g vs 10.53 g). Otherwise, the color of feather doesn't occur any effect ($P>0.05$) onto weight loss. However, there is no significant effect ($P>0.05$) for internal quality of eggs. Concerning storage duration, it affected significantly the parameters of internal quality of eggs ($P<0.001$) such as height of egg yolk, height of white, egg yolk's diameter, albumen and yolk index, Haugh unit. The best parameters were recorded from eggs storaged between 1 and 5 days. In the same way, eggs loss weight was significantly affected by storage time which ranged from -0.06 g to - 0.22 g. Relation between storage duration and color of feather affected significantly the level of eggs albumen.

Keywords: color of feather; storage duration; quality; eggs; quail.

1. Introduction

Poultries have interesting characteristics which show out the interest for the breeder to use them as a way to participate in the filling of the deficit in animal proteins. Therefore, the poultry sector focused on chicken, contributed to 103 million tons of meat and 66.4 million eggs intended to the global consumption in 2012 [1]. However, this production stays insufficient due to the projection of the FAO which foresees an increase of the world population as well as that of the Côte d'Ivoire around 70% [2] until 2050. In order to cover this high demand of animal protein, it is so necessary to diversify the breeding of animals precisely those having short cycle production like, fowls, quails. Thus, quail farming could serve as an alternative way to cover protein requirements and reduce pressure on chicken production.

Moreover, the improvement of quail breeding was undertaken in order to shut out their zootechnical characteristics very interesting such as the earliness of the bird concerning meat production (about 5 weeks of age), its better performance concerning laying which range from 200 to 300 eggs per year and at last its short generation interval compared to other avian species.

In spite of its interesting zootechnical characteristics and its economic interest, the quail is at the origin of other interests which are in different scientific domains for example in the neurosciences, the animal physiology and more singularly genetics [3, 4]. Otherwise, the goal of the different breeding of species depend mainly on the selection way and every reared strains present specific performances. It justifies therefore the significant heterogeneity within the population of quail [5].

Furthermore, the japanese quail exhibits diversity in morphological and phenotypic characteristics according [6] precisely the diversity in form including feather color [7]. Indeed, the genetics of Japanese quail's feather got both interests such as a biological standpoint, for comparative studies among avian species, and a zootechnical standpoint, for identifying commercial selection lines or crosses [8]. It is so this heterogeneity in the quail population which would affect its eggs production, as well as internal and external quality of eggs.

Nevertheless some factors beyond the scope of genetics can also affect the production and quality of the egg. Otherwise, Reference [9] defined the quality of the egg as the characteristics that make its consumption

acceptable and its hatching possible. This quality is mainly influenced by genotype and age concerning chicken. Thus, many studies have shown that the genotype indeed influences the weight of the eggs [10, 11, 12], its form index [10, 11] and its Haugh unit [13, 10]. In addition, storage time can also affect the quality of eggs including weight, shape index, albumen height, Haugh index [10].

Otherwise, in the quail population, eggs stored until ten days show the best hatchability [14]. Moreover, many studies have been conducted on the quality of eggs in the population of poultry. However, few researches have been done on the quality of quail eggs raised in subtropical Africa area, particularly in Côte d'Ivoire, where the climate is hot.

The current study was undertaken in order to examine the effect of genetic factors influencing feather color (yellow and common (brown)) on egg quality parameters of the japonica quail reared in sub-tropical climate. Specifically, the aim of this study is to compare the internal and external quality of the eggs of two quail genotypes according to storage time.

2. Materials and methods

2.1 Materials

The eggs used in this research, come from two groups of 45 quails per genotype. In fact, 780 eggs were collected and stored during 13 days for two genotypes of quail according feather color (yellow feather and wild-type feather namely Brown), at a rate of 30 eggs per day and per genotype. The *yellow* mutation in the Japanese quail (*Coturnix japonica*) is controlled by an autosomal incomplete dominant gene (*Y*). The data was collected using a 0.01g precision digital scale, a 0.01mm precision caliper, and graph papers. The eggs' quality test consisted of removing a sample of 11 eggs per day of storage in every group just before incubation in order to measure the internal and external parameters of eggs quality.

2.2 Collected Data

Concerning the external quality, the eggs were weighed individually according the day of lay (P1) and just before incubation with an analytical electronic scale. The length and width of the eggs (measured at the widest tip) were recorded with a 0.01mm precision electronic caliper. The egg shape index was calculated using the formula below:

$$Egg\ shape\ index\ (\%) = \frac{width\ (cm)}{length\ (cm)} \times 100 \quad (1)$$

For internal quality, the yolk and albumen length, height and width were determined by using a caliper (mm). Subsequently, the yolk was separated from the albumen with a spatula. Digital electronic scale was used for weighing the eggs precisely the weight of eggs' yolk and albumen. These values were used to determine the yolk index and the haugh unit. The advantage of the measurement of yolk index is linked to the fact that it permits to evaluate physical state of yolk which gives an idea about the age of eggs. Yolk index is the ratio between the height and the diameter of the eggs' yolk. Indeed, eggs' yolk height (cm) measurement was done by

a vertical bite in the middle of the yolk using toothpick and its interpretation by comparison of this height thanks to a caliper. Concerning, the determination of yolk diameter (cm), it was read directly on the caliper. The Yolk index (YI) was calculated according the following formula [15].

$$Yolk\ Index\ (YI) = \frac{Yolk\ Height\ (YH)}{Yolk\ Diameter\ (YD)}\ X\ 10 \quad (2)$$

The Haugh unit was determinated by the height of albumen and eggs weight. The advantage of Haugh units' determination is the fact that it permits to evaluate the consistency of the albumen and it allows to have information about the shape of eggs deterioration and eggs quality. Haugh unit (H.U) was calculated according formula used by [16].

$$UH = 100log\ (H - 1{,}7W0.37 + 7.57) \quad (3)$$

Where; H.U = Haugh Unit, H = Observed albumen height, W = Observed weight of egg in gram and 7.57 = Weight correction factor of the egg.

2.3 Statistical analysis

All the data of egg quality were first entered in the Excel 2013 table and then analyzed using the R version 3.1.0 statistical software. The analysis of the variance was done in order to determine the level of the significance difference between the results at P = 0.05 threshold. The significance of differences among the genotypes was carried out by the Tukey's test at the levels of significance indicated. The tests used in our study were the Student's t-test, the ANOVA and the post-ANOVA tests (test LSD (Least Statistic Difference)). The analysis focused not only on the external quality (length, width, shape index), but also on internal quality (Haugh unit, yolk index) of eggs. The factors considered in this study are storage duration and the color of feather.

3. Results

Results concerning the evolution of egg weight relative to feather color are shown in table 1. A significant (P <0.001) effect of feather color was observed for the initial weight and the final average weight. The brown variety of quail (wild-type quail) has recorded higher initial weight averages than the yellow variety, such as respectively 10.75 ± 0.86 g and 10.54 ± 0.82 g. The final weight averages range as well as the initial weight averages with 10.64 ± 0.89 g for wild-type quail (brown variety) against 10.41 ± 0.84 g for yellow quail. However, effect of the feather color was not significant on eggs weight loss (P> 0.05).

The results of variance analysis concerning the external quality of egg are shown in table 2. Feather color exhibited the high significant (P <0.001) effect for all parameters. The low mean of the length of egg (29. 94 mm) was recorded in the population of yellow quail. The same range was observed for the width of egg parameter with 23.65 mm for yellow quail while that of wild-type quail was 25.17mm. Similarly, the low form index of eggs was found in the population of yellow quail.

Moreover, in the table 3 which shows the results of the parameters of internal eggs quality according feather color, statistical analysis in indicate that the effect of genotype was not significant (P>0.05). Whatever the female's genotype, the parameters of eggs don't range.

Otherwise, the averages of internal quality parameters of quail eggs conforming to storage duration are reported in table 4. Storage duration, significantly influences all studied egg quality parameters (P <0.001). However, for yolk height, albumen height, yolk index, and Haugh unit, there is no significant difference between the storage duration of [6; 10,11; 13] days. For the same internal quality parameters, the period of [1; 5] days present higher averages than the periods of [6; 10,11; 13] days. Indeed, yolk's height was 9.62 mm for a storage period between 1 and 5 days ([1; 5]) while those of [6; 10,11; 13] days are respectively 8.04 mm and 8.07 mm. Similarly, the albumen height was 5.10 mm for the period of [1; 5] days against 4.39 mm and 4.42 mm for the periods of [6; 10,11; 13] days. The yolk index obtained was 0.39 for [1; 5] days against 0.30 % and 0.29 % respectively for [6; 10,11; 13] days and the Haugh unit was 93.03 ± 5.49 for [1; 5] days against 89.42 ± 4.97 and 89.50 ± 4.70 respectively for [6; 10,11; 13] days. However, concerning yolk diameter and weight loss, the averages varied and depended on storage tduration. Indeed, if the storage period is higher, the diameter average of the yolk and the weight loss are high (from 24.92 to 28.17 mm and from 0.06 to 0.22 g, respectively).

Effects of color, storage duration and their interaction on egg quality parameters are summarized on table 5 and 6. A significant genotype x storage duration interaction was observed for the yolk and albumen heights. Specifically, it was observed that the storage duration had less effect on the eggs of the yellow phenotype birds concerning yolk height (from 9.98 mm to 8.42 mm) compared to those of wild-type birds. The same observation was found for the albumen height mean (from 4.86 mm to 4.56 mm). Furthermore, the interaction had more impact on albumen height (to 9.84 mm at 7.67 mm) of eggs from the brown phenotype. This same trend was observed with albumen height mean (from 5.34 mm to 4.24 mm).

Table 1: Evolution of eggs weight average according to birds' feathers color (yellow or wild-type)

Parameters	**Yellow quail**	**Wild-type quail**	**t**	**p**
	M±ET	**M±ET**		
Initial weight (g)	10.54 ± 0.82^{b}	10.75 ± 0.86^{a}	3.56	<0.001
Final weight (g)	10.41 ± 0.84^{b}	10.64 ± 0.88^{a}	3.736	<0.001
Weight loss (g)	0.12 ± 0.16^{a}	0.11 ± 0.18^{a}	1.2495	0.2118

M ± SD: mean ± standard deviation, $^{a\ b}$Means with different superscript in the same row are significantly (P<0.001) different .

Table 2: External quality of the egg according to birds' feather color (yellow or wild-type)

Parameters	**Yellow quail**	**Wild-type quail**	**T**	**P**
	M±ET	**M±ET**		
Length (mm)	29.94 ± 1.51[b]	31.55 ± 1.38[a]	15.481	<0.001
Width (mm)	23.65 ± 1.15[b]	25.17 ± 0.75[a]	21.794	< 0.001
Egg Index (%)	79.10 ± 0.03[b]	79.80 ± 0.03[a]	3.4803	< 0.001

M ± SD: mean ± standard deviation, [a,b]Means with different superscript in the same row are significantly (P<0.001) different .

Table 3: Internal quality of the egg according to the birds' feather color

Parameters	Yellow quail	**Wild-type** quail	t	p
	M ± ET	M ± ET		
Yolk Height (mm)	8.68 ± 1.36[a]	8.62 ± 1.58[a]	0.314	0.753
Albumen Height (mm)	4.62 ± 1.07[a]	4.73 ± 1.06[a]	0.837	0.403
Yolk Diameter (mm)	26.31 ± 2.62[a]	26.51 ± 2.01[a]	0.703	0.482
Yolk index (%)	33.29 ± 0.06[a]	32.94± 0.08[a]	0.413	0.6801
Haugh units	90.61 ± 5.36[a]	91.05 ± 5.43[a]	0.694	0.487

M ± SD: mean ± standard deviation, [a,b]Means with different superscript in the same row are significantly (P<0.001) different .

Table 4: Internal quality of the egg depending on the storage duration.

Storage duration (day)	**Yolk Height (mm)**	**Albumen Height (mm)**	**Yolk Diameter (mm)**	**Yolk index (%)**	**Weight loss (mm)**	**Haugh units**
[1 - 5]	9.62 ± 1.55[a]	5.10± 1.10[a]	24.92± 1.95[c]	38.88 ± 0.07[a]	0.06 ± 0.13[c]	93.03± 5.49[a]
[6 - 10]	8.04 ± 1.02[b]	4.39± 0.99[b]	26.83± 1.94[b]	30.03± 0.03[b]	0.14 ± 0.15[b]	89.42± 4.97[b]
[11 - 13]	8.07 ± 1.09[b]	4.42± 0.88[b]	28.17 ± 2.05[a]	28.64± 0.04[b]	0.22 ± 0.26 [a]	89.50± 4.70[b]
F	27.535	7.5812	54.5934	63.3261	50.9188	16.78
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

M ± SD: mean ± standard deviation, [a,b]Means with different superscript in the same coloumn are significantly

(P<0.001) different .

Table 5: Effect of color, storage duration and their interaction

Variables	Effect of color	Effect of storage duration	Effect of color x storage duration
Yolk height	NS	***	**
Albumen height	NS	***	**
Yolk diameter	NS	***	NS
Weight loss	NS	***	NS
Yolk index	NS	***	NS
Length of eggs	***	NS	NS
Width of eggs	***	NS	NS
Eggs index	***	NS	NS
Initial weight	***	NS	NS
Final weight	***	NS	NS
Weight loss	NS	NS	NS
Haugh unit	NS	***	NS

*NS means not significant, *significant, **very significant, *** highly significant*

Table 6: Effect of interaction between feather color and storage duration on egg yolk and albumen height.

Storage duration	**Yolk height**		**Albumen height**	
	Yellow	Wild-type	**Yellow**	Wild-type
	M ± ET	M ± ET	M ± ET	M ± ET
[1 - 5]	9.39 ± 1.09^{a}	9.84 ± 1.21^{a}	4.86 ± 0.75^{a}	5.34 ± 0.90^{a}
[6 - 10]	8.11 ± 1.06^{b}	7.97 ± 0.76^{b}	4.37 ± 0.96^{b}	4.40 ± 0.61^{b}
[11 - 13]	8.42 ± 0.81^{b}	7.68 ± 0.92^{b}	4.56 ± 0.85^{b}	4.25 ± 0.77^{b}
F	4.927		3.468	
P	P<0.01		P<0.05	

4. Discussion

Statistical analyzes showed that quail eggs having Wild-type plumage (brown) are larger and heavier than those of quail with yellow feather. This genetic difference among varieties of quail has been also found by previous studies in quails [17, 18, 19, 20] and in chickens [21]. However, egg weight means recorded in this study (10.54 g for yellow quail and 10.75 g for wild-type quail) are lower than the results of [18]. These researchers found

11.2 g for yellow quail and 11.4 g for wild-type quail (brown). Weight loss was not affected by the feather color of the female.

The length mean of eggs in our study (31.55 mm for common quails) is inferior to that found by [17]. These authors found a value around 33.22 mm. The egg width mean such as 25.168 mm is as well as lower than those of [17] (26.35 mm). However, the shape index reported in our study (79.8 %) is in accordance with anterior findings [17, 18] with a value around 79.3. These authors also found out that the shape index depends on the color of feather.

The present research showed that the feather color does not affect the internal quality (yolk height, albumen height, yolk diameter, yolk index, Haugh unit) of the quail eggs ($P>0.05$). This finding is in agreement with that recorded by [17]. The higher datas of Haugh unit found in our study (90.61 and 91.05) represented one of the main parameter for characterizing eggs on the market according to [22].

The values of the Haugh unit in our study are the same to those reported by [18] who found out 90.0 for yellow quail and 91.9 for wild-type quail. However, these results in the population of wild-type quails are higher than those reported by previous authors [17, 20]. These authors found values of 79.81 and 87.41 in the population of quails having the same feather. The value of the Haugh unit decreases with the storage period. These results were confirmed by the researches of [10] and [23] in the population of chicken.

The best quality of eggs was observed from storage duration between 1 and 5 days. These results are similar to those of other studies [24, 25] who detected that the quality of quail eggs was affected beyond 7 days of storage.

The yolk height in the population of common feather quail (8.62 mm) is similar to that reported by [20] for quails having the same phenotype as 8.87 mm, while the yolk diameter (26.506 mm) was better than that found out by [20] (17.4 mm) in the population of quails with wild-type feather.

The yolk index was lower (33.3 % for yellow quail and 32.9 % for wild-type quail) than those found in previous study [17, 18]. These authors recorded respectively 44.7 % for yellow quail and from 44.89 % to 45.6 % for wild-type quail.

However, the internal quality of the eggs is influenced by the storage duration [10, 23]. The best eggs quality was for eggs stored during the period of 1 and 5 days. These results correspond with previous works [24, 25] which found that eggs quality is deteriored after 7 days of storage. On the other hand, Haugh unit recorded in our study such as 93.03 and 89.42 respectively for storage period of [1- 5] and [6- 10] at ambient temperature are higher than those found by [26]. Indeed, this author reported values of 56.0 and 54.5 for 4 and 7 days of storing. Moreover, storage duration influenced significantly eggs' diameter and height. These parameters values change when storage duration increases. In fact, yolk diameter increases while albumen height decreases. This fact would certainly be due to the relaxation of the yolk membrane which finally breaks.

Similarly, storage duration significantly ($P <0.001$) influenced the evolution of egg weight. Indeed, the weight of the eggs has been significantly reduced with a greater loss beyond 10 days of storage. This result coincides

with the work of [23] who worked on the egg of laying hens. In addition, Reference [27] showed that egg quality parameters increased at egg-laying period and decreased significantly with prolonged storage.

The interaction between storage duration and feather color (yellow and wild-type) of the female was significantly for yolk height ($P < 0.01$) and for albumen height ($P < 0.05$) of the eggs. This interaction is more noticeable by the deterioration of eggs from female having brown feather than female with yellow feather at the level of yolk and albumen height.

5. Conclusion

This study showed that the external quality of quail eggs (egg weight, length and width) is affected the quail genotype. Concerning, the internal quality of the eggs, it depends on the period of storage. The longer storage period, affect more the internal quality of the egg characterized by deterioration.

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