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Physical characteristics of eggs from Mexican Creole, Hy-Line Brown and Rhode Island Red hens in intensive production

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ABSTRACT

Objective: To characterize the egg from three hen genotypes: Mexican Creole (MC), Hy-Line Brown (HLB) and Rhode Island Red (RIR).

Design/Methodology/Approach: Three groups of each genotype were formed using 75 hens (30 MC, 30 HLB and 15 RIR), 20 weeks old. Daily, for 84 days, two eggs were chosen randomly from each group to determine: weight (w, g), length (L, cm), width (Wth, cm), shape index (SI), volume (VOL, cm^3), area (AR, cm^2), shell color (SCo), yolk color (YCo), white weight (WW, g), yolk weight (YW, g), shell weight (SW, g), white proportion (WProp), yolk proportion (YProp), and shell proportion (SProp). The means were compared with Tukey's test, $P<0.05$, using the SAS software.

Results: The genotype HLB was superior ($P<0.05$) in W, Wth, SI, VOL, AR, SCo, WW, and WProp (61.220 g, 4.400 cm, 0.801, 55.890 cm^3, 71.723 cm^2, 6.834, 38.030 g and 0.621, respectively). There were no differences between genotypes ($P>0.05$) in L (5.383 to 5.490 cm). The MC hens were superior ($P<0.05$) in YCo, YW and SProp (6.738, 15.923 g and 0.132, respectively). The SW differed ($P<0.05$) between genotypes: HLB (7.550 g), MC (6.661 g) and RIR (6.205 g). MC and RIR had higher ($P<0.05$) YProp (0.314 and 0.304, respectively) than HLB (0.250).

Study Limitation/Implications: The study contemplated only one part of the production period of the birds.

Findings/Conclusions: Each genotype produced egg with particular physical characteristics, with Creole hens standing out due to their high values of yolk color and proportions of yolk and shell.

Keywords: Dish egg, physical characteristics, Mexican Creole, Rhode Island Red, Hy-Line Brown.

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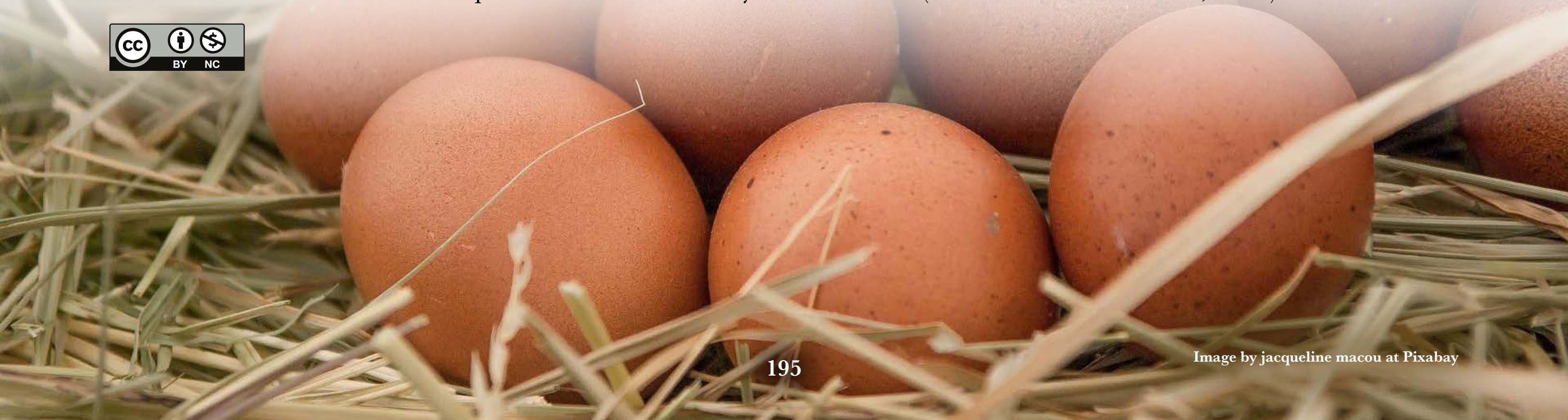
INTRODUCTION

The physical characteristics of egg are important from the biological and economic point of view (Mine and Kovasc, 2004; Moulo *et al.*, 2010; Alkan *et al.*, 2013), and some of the most important are the following: weight, thickness and porosity of the shell, length, shape index and consistency of the content (Narushin and Romanov, 2002). When it comes



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to the consumer, egg quality is determined by additional characteristics to those already mentioned: cleanliness, freshness, surface area, mass, volume, packaging coefficient, and shell quality (Narushin, 1997; Duman *et al.* 2015). Likewise, egg quality includes aspects related to the shell, the albumin and the yolk (Ahmadi and Rahimi, 2011; Yang *et al.*, 2014; Duman *et al.*, 2015).

Many laboratory techniques have been developed to determine the egg quality in hens of commercial varieties (Abadia *et al.*, 1998). On the contrary, little is known about the egg quality of Creole hens in Mexico (Juárez-Caratachea, 2010). Researching Creole hens takes on great scientific, social and economic importance, given the current interest in the conservation of zoogenetic resources (VillacisVillacís, 2014; Andrade *et al.*, 2015). In a study conducted by Andrade *et al.* (2015) about the physical characteristics of eggs from Campera and Creole hens found that eggs from Campera hens showed the best results in terms of weight, width and length (55.4 g, 41.9 and 54.9 mm, respectively). Although the study concludes that Campera hens outperform Creole hens in the variables studied, it would be important to conserve Creole hens as a genetic resource because aspects about their productive performance are still unknown as are characteristics of the egg and meat they produce. In a study conducted in an intensive system, Segura-Correa *et al.* (2007) reported an average weight of the first egg from Creole hens of 45.3 g. Cuca-García *et al.* (2015) found that the average weight of eggs collected in some localities of Estado de México, Morelos and Tlaxcala was 50 g, and the average size of width and length (5.7 cm and 4.0 cm, respectively) in backyard conditions.

Based on this, it is clear that little is known about the physical characteristics of the egg (weight, length, width, shape index, volume, area, shell color, yolk color, white weight, yolk weight, shell weight, white proportion, yolk proportion, and shell proportion) of Mexican Creole hens, and likewise it is unknown whether these characteristics differ from other genotypes of hens available in Mexico such as Rhode Island Red and Hy-Line Brown.

Based on the background described, the objectives of this study were to characterize the eggs from Mexican Creole (MC), Rhode Island Red (RIR) and Hy-Line Brown (HLB) hens in terms of different physical properties of the egg, and to understand the differences between those genotypes.

MATERIALS AND METHODS

Location and period

This study was conducted from September to November, 2021, with duration of 84 d, in the Experimental Poultry Farm of the Zoology Department of Universidad Autónoma Chapingo, located on km 18.5 of the Los Reyes-Lechería, Texcoco highway, Estado de México. The place is located on coordinates: 19° 29' 13.1" latitude North and 98° 53' 47.2" longitude West and the region's climate is classified as C(w2)(w)b(i')g, which corresponds to a temperate sub-humid climate with summer rains, according to García (2004).

Bird management

The birds were placed in a shed with natural environment, with lateral mobile shutters and North-South orientation. Seventy-five (75) hens were used (30 Mexican Creole, 30 Hy-

Line Brown and 15 Rhode Island Red), 20 weeks old. The birds were housed in individual cages, and the dimensions of each cage were 30 cm wide, 45 cm deep, 36 cm tall on the superior part and 41 cm tall on the frontal part. The cages are pyramidal modules of two levels (5 cages per level and 20 cages per module). Each cage had 30 cm of metal sheet feeding trough and a cup-type automatic water dispenser. A lighting program of 16 hours of light and eight hours of darkness was used. Water and feed were offered with unrestricted access. The diet used was proposed based on the nutritional needs recommended for laying birds (NRC, 1994) (Table 1).

Genotypes and variables

The birds were housed in individual cages. Three groups were formed with 10 birds of each genotype, MC and HLB, and three groups of five birds of the RIR genotype. For the 84 d of the experiment, two eggs were collected daily and randomly from each group, for as long as the bird production would allow it. Likewise, daily, the following were

Table 1. Composition (%) of the experimental diet for Mexican Creole, Rhode Island Red, and Hy-Line Brown hens.

Ingredient	%
Corn	36.72
Soybean meal	31.67
Calcium carbonate 38%	11.05
Vegetable oil	17.44
Calcium phosphate 21/17*	2.04
Sodium chloride	0.38
Vitamin premix	0.30
Methionine 99%	0.35
L-Threonine	0.05
Total	100.00
Calculated nutrient content	
Metabolizable energy (kcal/kg)	2880
Crude protein (%)	18.230
Digestible arginine (%)	1.126
Digestible lysine (%)	0.905
Digestible methionine + cystine digestible aves (%)	0.800
Digestible tryptophan (%)	0.202
Digestible threonine (%)	0.620
Digestible isoleucine (%)	0.694
Digestible valine (%)	0.738
Linoleic acid (%)	9.512
Calcium (%)	4.510
Non-phytic phosphorus (%)	0.530
Sodium (%)	0.190
Chloride (%)	0.233

*21% calcium, 17% phosphorus.

measured in the eggs selected: weight (W, g), length (L, mm), width (Wth, mm), shape index (SI), volume (VOL, cm^3), area (AR, cm^2), shell color (SCo), yolk color (YCo), white weight (WW, g), yolk weight (YW, g), shell weight (SW, g), white proportion (WProp), yolk proportion (YProp), and shell proportion (SProp). During the entire experimental phase, a total of 1465 eggs were evaluated (504, 502 and 459 of Mexican Creole, Hy-Line Brown and Rhode Island Red, respectively). The variable W was determined with an electronic scale of 500 g capacity and 0.01 g precision (Model MH-200, Brand MKS TOOLS). The L and Wth of each egg were measured with a Vernier (Model HER-411, STEREN) with a measurement range of 0 to 150 mm and 0.1 mm of resolution. The L was determined on the longitudinal axis of the egg and the Wth on the transversal axis at the half height of the longitudinal axis. The SI was calculated using the following formula by Duman *et al.* (2016):

$$SI=(Wth/L)\times 100$$

The variables VOL and AR were calculated with the expressions

$$VOL=0.913\times W$$

and

$$AR=0.558\times P\ 0.67$$

respectively, according to Etches (1996): in both expressions W refers to the egg weight. The SCo was determined based on the ZIMPRO® range of colors with a scale of nine tonalities. The YCo of each egg was determined with the Ovocolor BASF® color range with a scale of 15 colors. The variables WW, YW and SW were obtained with an electronic scale of 500 g of capacity and 0.01 g of precision (Model MH-200, Brand MKS TOOLS), and for that purpose the weight of each whole egg was recorded, then it was broken and with the support of an egg white separator each component of the egg was separated to record their weight. The values WProp, YProp and SProp were calculated with regards to the weight of the whole egg.

Statistical analysis

The design was completely random, where the hen genotype was the only factor. The values of the variables from each pair of eggs were averaged and considered as the experimental unit. The data were analyzed with the MIXED procedure of the SAS statistical software (SAS Institute Inc., 2011) under the general linear model and the means were compared using Tukey's test ($P<0.05$).

RESULTS AND DISCUSSION

The egg from Hy-Line Brown hens produced higher values ($P<0.05$) of the variables W, Wth, SI, VOL and AR (61.220 g, 4.400 cm, 0.801, 55.890 cm^3 and 71.723 cm^2, respectively) compared to the egg from Creole Mexican or Rhode Island Red hens (Table 2), and no differences were detected (P>0.05) for those variables between these two genotypes. Likewise, differences were not detected (P>0.05) in egg L of the three genotypes (5.383 to 5.490 cm). The variables SCo, WW and WProp were different between genotypes (P<0.05) with higher values for the egg from Hy-Line Brown hens (6.834, 38.030 g and 0.621, respectively), followed by Rhode Island Red (5.124, 29.122 g and 0.579, respectively), and with lower egg values from Creole Mexican hens (2.688, 28.023 g and 0.553, respectively). In contrast (Table 2), the egg from Mexican Creole hens was superior (P<0.05) than the egg from Rhode Island Red and Hy-Line Brown hens, in terms of YCo, YW and SProp (6.738, 15.923 g and 0.132, respectively). Finally, differences were also observed between genotypes (P<0.05), for the variable SW: the egg from Hy-Line Brown hens had the highest value (7.750 g), followed by Mexican Creole (6.661 g) and Rhode Island Red (6.205 g). Regarding YProp, the egg from Mexican Creole and Rhode Island Red hens (0.314 and 0.304, respectively) had a higher value compared to Hy-Line Brown (0.250).

The eggs from genotype Hy-Line Brown had higher values in the variables W, Wth, SI, VOL, AR, SW, WW, and SProp. These results can be due in large part to this genotype being a commercial line that has been improved through time for particular physical characteristics, in contrast with the Creole birds. Rodríguez and Bravo (2019) studied egg weight in laying hens of the Hy-Line Brown line in the first laying phase and found average weights of 56.64 g, and a mean of 61.220 ± 0.242 was obtained in this study. The

Table 2. Adjusted means (± SE) of physical characteristics of egg from Mexican Creole with number of birds=30, number of eggs=504; Rhode Island Red with 15 birds and 459 eggs, and Hy-Line Brown with 30 birds and 502 eggs in intensive production.

Variable	Mexican Creole	Rhode Island Red	Hy-Line Brown
P (g)	50.650 ± 0.242 b	50.266 ± 0.253 b	61.220 ± 0.242 b
L (cm)	5.383 ± 0.078	5.407 ± 0.821	5.490 ± 0.786
A (cm)	4.005 ± 0.048 b	3.980 ± 0.050 b	4.400 ± 0.048 b
IF	0.757 ± 0.009 b	0.750 ± 0.009 b	0.801 ± 0.009 b
VOL (cm^3)	46.243 ± 0.221 b	45.893 ± 0.231 b	55.890 ± 0.221 b
AR (cm^2)	63.146 ± 0.198 b	62.796 ± 0.210 b	71.723 ± 0.199 b
CoCas	2.688 ± 0.050 b	5.124 ± 0.053 b	6.834 ± 0.050 b
CoYema	6.738 ± 0.060 b	6.390 ± 0.061 b	5.439 ± 0.058 b
PClara (g)	28.023 ± 0.186 b	29.122 ± 0.194 b	38.030 ± 0.186 b
PYema (g)	15.923 ± 0.182 b	15.220 ± 0.191 b	15.249 ± 0.182 b
PCasc (g)	6.661 ± 0.042 b	6.205 ± 0.044 b	7.750 ± 0.042 b
PropClara	0.553 ± 0.002 b	0.579 ± 0.002 b	0.621 ± 0.002 b
PropYema	0.314 ± 0.004 b	0.304 ± 0.004 b	0.250 ± 0.004 b
PropCasc	0.132 ± 0.000 b	0.124 ± 0.000 b	0.130 ± 0.000 b

a,b,c Means with different letter within each row are different (P<0.05). EE: standard error. P: egg weight, L: egg length, A: egg width, IF: shape index, VOL: volume, AR: area, CoCas: eggshell color, CoYema: yolk color, PClara: white weight, PYema: yolk weight, PCasc: eggshell weight, PropClara: white ratio, PropYema: yolk ratio, PropCasc: eggshell ratio. N: number of birds, n: number of eggs per genotype.

longitudinal and transversal diameters are associated directly with the egg's weight; that is, the heavier eggs have diameters that are also larger and vice versa. Regarding the egg weight, North and Bell (1998) and Andrade *et al.* (2015) point out that it depends mainly on the bird's age, size of the yolk, and environment of production and of the diet.

The shape index has a very significant effect on the resistance to squashing (Anderson *et al.*, 2004). Therefore, characteristics such as shape index and shell thickness avoid the risk of producing broken eggs and, this way, eggs of better quality are obtained. Duman *et al.* (2015) found a statistically significant positive correlation between the egg's shape index and the egg's superficial area ($P<0.005$). Eggs could be ordered from higher to lower in terms of the superficial area as round, standard and defined. These results agree with the findings by Alkan *et al.* (2013). According to Nordstrom and Ousterhout (1982), the shell weight is significantly and positively influenced by the egg weight. These authors found that 47% of the variation in the weight of the egg shell was due to the egg weight; therefore, this explains the result that was obtained in the variable shell weight (SW) on the Hy-Line Brown genotype. The proportions change, particularly in function of the egg size and indicate that the large ones contain less proportion of yolk than the small ones, which agrees with Delpech (1980). This is why the size of the eggs from the Hy-Line Brown genotype is closely correlated with the proportion of white, as well as with the other variables: weight, width, shape index, volume, area, white weight, shell weight, and white proportion.

The yolk color is determined by the hen breed and does not have anything to do with its quality, nutritional value or flavor (Suárez-Diéguez, 2021). Finally, the trend towards presenting a lighter yolk color (less content of xanthophyll) agrees with what was mentioned by Barrantes *et al.* (2006), who state that commercial eggs present lower color in comparison to the eggs obtained in a grazing system. That is, Creole hens probably produce more yolk color, since they are bred in the backyard, so their eggs present a similar yolk tone to those of grazing hens.

Abudabos *et al.* (2017) mention that the eggs from Creole birds can vary in weight and size depending on the age of the hens. Juárez-Caratachea *et al.* (2010) report that the average size of the egg from Creole hens is lower than from hens of commercial lines, while Jerez (1999) reports in trials with artificial incubation of Creole egg, that from the total of non-incubating egg, 8.97% was selected because it was small egg (65 g). In a study conducted by Segura-Correa *et al.* (2007), the average weight of the first egg from Creole hens was 45.3 g and increased with age until reaching 60.7 g at 39 weeks. The lower weight of the first egg and of the egg during the laying period from Creole hens, in comparison to commercial hens, is because the first were not selected for a larger size of the egg.

The genotype of the Creole Mexican hens has some particularities that are considered important. The Creole hens have statistically higher results in the variables YCo, YW, YProp and SProp. The yolk color is a variable that has been considered in recent years as a quality factor of the egg. This indicates that the yolk color depends on natural or artificial pigments in the feed consumed by the birds (Mikova *et al.*, 2014). A very intense color is rather demanded in the market, which is why the darker yolk is more pleasant when the egg is cooked or fried (RCAN, 2008). The color of a food continues to be one of the organoleptic factors of greatest importance for the consumer. Food color can indicate quality and freshness (Manguregui, 2020). Danilov (2000) and Islam and Dutta (2010) point out that the ratio between weight, length and width of the eggs, and the proportion of yolk, albumin and shell increased with the egg weight, and this increase is in relation with the age of the hen, reaching a plateau at the end of the laying cycle. In addition, the embryonic development of the hen egg depends on variables similar to those already mentioned, particularly of the yolk and the genetic line (Finkler *et al.*, 1998; Onagbesan *et al.*, 2007).

The internal characteristics of the egg quality, such as yolk weight and albumin weight, are very important from the nutritional point of view (Bain, 2005; Islam and Dutta, 2010). Although knowledge of the proportions of the white and the yolk have low interest for consumers, due to their relation with egg breakage, they have great importance for the poultry and dietary industries. These proportions change, particularly in function of the egg size: the largest have less proportion of yolk than the smallest (Delpech, 1980). This information explains the result that was obtained with the variable yolk proportion, whose mean was 0.314±0.004. It should be highlighted that in this study, the Mexican Creole genotype produced smaller eggs compared to the Hy-Line Brown genotype. The Rhode Island Red genotype produced few significantly high values in most of the variables studied. Only the variable YProp, from the Creole and from this genotype, was higher than that of the Hy-Line Brown genotype. The result obtained is directly related to the egg weight. As has been mentioned, the yolk weight depends directly on the egg weight. It is important to highlight that all the physical and morphological characteristics are closely correlated with the egg weight. Hanusová *et al.* (2015) obtained an egg weight that is affected significantly ($P \leq 0.01$) by the breed. The eggs from the Oravka breed hens were heavier (60.96±0.56 g) than those from the Rhode Island Red breed (57.60±0.76 g). In this study, the egg weight from Rhode Island Red hens was 50.266±0.253 g. This type of results depends on many factors, primarily genetic and dietary. The egg weight of the Raza Rhode Island Red breed found by Monira *et al.* (2003) was 57.20 g.

In addition, in the study by Hanusová *et al.* (2015) the weight of the white was significantly higher ($P \leq 0.05$) in the Oravka breed (34.96±0.58 g) compared to the Rhode Island Red breed (32.78±0.73 g). These results are similar to those obtained in this study, where the Rhode Island Red genotype resulted in a value of 29.122±0.194 g, followed by Hy-Line Brown (38.030±0.186 g). These weights of whites were higher ($P<0.05$) than the value obtained with the Creole genotype (28.023±0.186).

CONCLUSIONS

Eggs from the genotypes of the birds studied showed particular physical characteristics that distinguish them. The egg from Hy-Line Brown hens had higher values in some characteristics of commercial importance, among which the egg weight and the white proportion stand out. However, the egg from Mexican Creole hens was characterized by having better values in other characteristics that are also important for the consumer, such as yolk color, or for egg handling, such as shell proportion. The egg from Rhode Island Red hens showed similar values to those of two other genotypes in different characteristics. It is advisable to conduct a larger study to improve the egg from Creole Mexican hens.

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