# CORRELATION AMONG THE MAIN PARAMETERS OF EGGSHELL QUALITY ANALYSIS OF HEN AND QUAIL EGGS[1]

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Abstract: Sixty fresh hen eggs and 60 quail eggs were used in an experiment conducted at UFRRJ in order to survey the correlation between the eggshell quality measurements by average of the following parameters: specific gravity, breaking strength, percentage and thickness of the shell. For hen eggs, specific gravity demonstrated a higher correlation (p <0.05) with shell thickness as compared to other methodologies; the breaking strength correlated with the shell percentage and shell thickness. In quail eggs, there was no correlation (p> 0.05) between specific gravity with the other shell quality analyses. There was a correspondence between breaking strength with the percentage and the thickness of the shell, this ratio was higher for the percentage of shell. For hen eggs, the measurement of the specific gravity method used in commercial poultry farms was adequate to indicate good shell quality in accordance with great correlation with shell thickness. However, the evaluation of shell quality through the specific gravity for quail eggs needs adaptation in the methodology for egg morphology for this species. The parameters of shell quality surveyed: specific gravity, breaking resistance, percentage of shell and thickness of shell in hen eggs showed a positive correlation to a moderate degree (0.54). For quail eggs, the shell percentage shows moderate match (0.60) only with breaking strength and shell thickness.

Key words: eggshell thickness, specific gravity, percentage of eggshell, breaking strength.

# CORRELAÇÃO ENTRE OS PRINCIPAIS PARÂMETROS DE ANÁLISE DE QUALIDADE DE CASCA PARA OVOS DE GALINHA E DE CODORNA

Resumo: Utilizou-se 60 ovos de galinhas e 60 ovos de codornas frescos, em um experimento conduzido na UFRRJ a fim de analisar a correlação entre as medidas de qualidade da casca ovos por meio dos seguintes parâmetros: gravidade específica, resistência à quebra, porcentagem e espessura da casca. Para os ovos de galinha, a gravidade específica demonstrou maior correlação (p <0,05) com a espessura da casca em comparação com as outras metodologias; a resistência à quebra se correlacionou com a porcentagem de casca e este parâmetro com a espessura da casca. Em ovos de codorna, não houve correlação (p >0,05) entre a gravidade específica com as outras análises de qualidade de casca. Houve correspondência entre a resistência à quebra com a porcentagem e a espessura da casca, sendo essa relação maior para a porcentagem de casca. Para ovos de galinha, a mensuração do método da gravidade especifica utilizado em granjas comerciais, é adequado para indicar boa qualidade de casca em função da maior correlação com a espessura da casca. Contudo, a avaliação da qualidade da casca através da gravidade específica para ovos de codorna necessita de adaptação na metodologia para a morfologia dos ovos dessa espécie. Os parâmetros de qualidade de casca analisados: gravidade específica, resistência a quebra dos ovos, porcentagem de casca e espessura da casca em ovos de galinha apresentam correlação positiva com grau moderado (0,54). Para ovos de codorna, a porcentagem de casca apresenta correspondência moderada (0,60) somente com resistência à quebra e espessura da casca.

Palavras-chaves: espessura da casca, gravidade específica, porcentagem de casca, resistência à quebra.

## INTRODUCTION

Among the most commonly used parameters for eggshell quality evaluation, the thickness, percentage and weight of this structure per area surface are considered direct evaluation, while specific gravity is defined as indirect evaluation. Direct assessments, although easy to read, require equipment such as semi-analytical scales (to weigh both eggs and shells) or micrometer (to measure shell thickness), in addition to the need to break eggs for its carrying out, with consequent loss of the product, which makes these methodologies more restricted to the research areas. Specific gravity (indirect assessment) is the most widely used by industries for not having to break the egg (JÁCOME et al., 2012).

Hempe et al. (1988) were the first researchers to report the direct relationship between the specific gravity (EG) of hen eggs and the percent of shell. According to Ramos et al. (2010), as birds become older there is a reduction in the thickness of the shell of the eggs produced by them, this fact is also accompanied by a reduction in specific gravity. The ideal values of specific gravity of hen eggs cannot be inferior to 1.080g/cm³ (SILVA, 2004). For quail eggs, the literature has described specific gravity values between 1.074 to 1.076 g/cm³, as found by Muniz et al. (2015) for eggs produced by quails fed three different commercial diets, during the laying period from 22 to 31 weeks of age. As in Lima et al. (2015), for quails of 26 to 35 weeks of age, values of 1.072 and 1.073 g /cm³ were found.

According to Abdallah et al. (1993), there is a decrease in the amount of eggs broken from the increase of the specific gravity of eggs, that **feature** having a high negative correlation (r =-0.96). According to the same authors, at each 0.001 g/cm³ increase in specific gravity, there is a 1.266% reduction in the percentage of broken eggs. Nevertheless, some aspects should be considered regarding the use of this parameter, mainly because it may be influenced by the temperature of the saline solutions, and also due to the calibration and incorrect readings of the equipment used to measure the density of the saline solution. Fissures in the eggshell and water movement of the solutions during the conduction of the analysis can also cause mistakes in the final result (VOISEY and HAMILTON, 1977).

Due to the little information on the reliability of the methods of eggshell quality measurements, new parameters and methodologies have emerged, in some cases replacing the traditional ones. According to Molino et al. (2009), the use of equipment to measure the eggshell breaking strength presents good results, but it is extremely expensive and complex. Another problem raised by these authors is the lack of standardization regarding the methods of carrying out, since different sizes of eggshell drilling probes can be used, as well as different equipment gaging speeds, which makes it difficult to compare the results.

Owing to the lack of research works comparing the parameters of analysis of hen eggshell, associated to the fact that no literature was found reporting the reliability of the methodologies used for the evaluation of the quality of quail eggshell, which presupposes that they were adapted from the techniques already commonly used in hen eggshells, this study aimed to evaluate by Pearson's correlation the degree of reliability among different parameters of shell quality evaluation commonly used for quail eggs and hen eggs.

## MATERIAL AND METHODS

The experiment was conducted in the Animal Products Laboratory, Universidade Federal Rural do Rio de Janeiro, Seropédica, RJ. Sixty eggs of six-week-old semi-heavy hens of the Dekalb Brown® strain, weighing, on average, between 63 and 67 g, and sixty eggs of 57-week-old Japanese quail (*Coturnix coturnix japonica*), standardized in weight between 11 and 12 g were used. All eggs used in the analyses were fresh (collected and stored for a maximun of 24 hours). The eggs of both the species were weighed, identified and subsequently the shell quality analyses were carried out in the order and methodology described below:

Specific gravity: it was determined by the saline flotation method, according to the methodology described by HAMILTOM (1982). The eggs were immersed in saline solutions with densities of 1.060; 1.065; 1.070; 1.075; 1.080; 1.085; 1.090; 1.095 and 1.100 g/cm³, prepared with the aid of an oil density meter (Incoterm 5582®), placed in growing order in containers identified from the first and so on until the eggs floated in the solution.

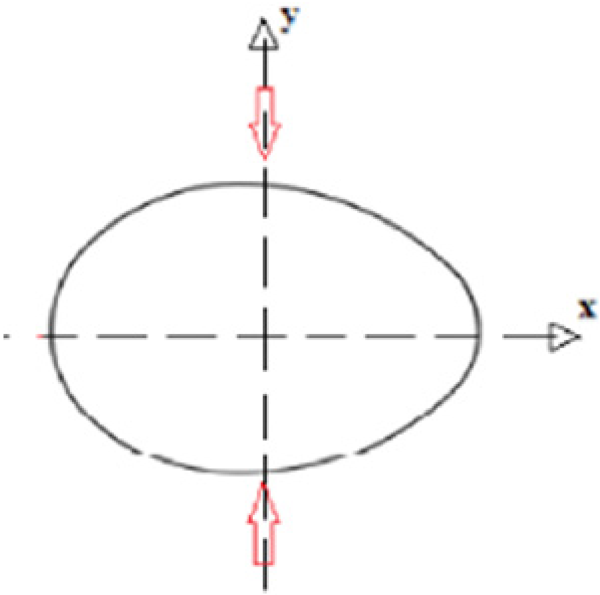


**Figure 1 -** Arrangement of the eggs for shell breaking strength analysis.
Adapted from Oliveira et al. (2014).

The eggshell breaking strength analysis was measured in a **shear** apparatus connected to a computer (for data transmission). For the hen eggs, a rupture probe of 36 mm in diameter was used and the equipment was calibrated with pre-test speed: 2.0 mm/s; test speed: 1.0 mm/s; post-test speed: 40.0 mm/s of depth: 1.0 mm. For quail eggs, a 2 mm rupture probe was used, a pre-test velocity of 2 mm/second; test speed 1.0 mm/second and post-test speed 40 mm/second. The eggs were arranged horizontally on a support adapted for this assay, so that the poles (major and minor) stayed on the X axis and the probe touched the equatorial region of the eggshell on the Y axis (Figure 1**).** An item of specific software was used to record the required force employed for total breaking of the bones in kilogram-force (Kgf), according to the methodology adapted from Oliveira et al. (2014).

After the analysis of eggshell breaking strength, the eggs were broken, washed and the shells dried in a ventilated oven at 105ºC for 2 hours. Next, the shell was weighed on an electronic digital scale with a precision of 0.01g. The percentage of shell was obtained by dividing the weight of the dried shell by the weight of the whole egg and multiplied by 100.

For measurement of the thickness of the eggshell, two samples were collected from the equatorial region of each shell of the eggs and measured with a digital micrometer (Mitutoyo®), being expressed as the mean of the two measurements on each shell.

The experiment was conducted in a completely randomized design with eggs from two species (hen and quail) with 60 replications each, each egg being considered an experimental unit. The correlations among the eggshell quality parameters were calculated by the Pearson linear method, analyzed by the BioEstat® Program.

## RESULTS AND DISCUSSION

The values of the eggshell quality parameters (Table 1) found for eggs of both species remained within the standards found in the literature for shell of good quality, based on specific gravity analyses in hen eggs (SILVA, 2004). ) and of quails (MUNIZ et al., 2015); eggshell thickness in hen eggs (STADELMAN and COTTERILL, 1995) and of quails (BARRETO et al., 2007; SILVA et al., 2010; LEMOS et al., 2012) breaking resistance and percentage of egg shell in hens (OLIVEIRA et al., 2014) and percentage of shell in quail eggs (LEMOS et al., 2017) and breaking strength in quail eggs (VIEIRA FILHO et al., 2016).

There was a positive correlation to a moderate degree (0.5 to 0.7) among all the eggshell quality parameters analyzed in hen eggs ($p < 0.05$), indicating that these correlate with each other with **v**ery similar values, which suggests positive reliability of using these characteristics to measure eggshell quality of this species (Table 2).

Specific gravity, which is commonly used in

**Table 1 -** Means of the values obtained from the chicken and quail eggshell quality methodologies

| | Analyses of Shell Quality | | | |
|---|---|---|---|---|
| | Specific Gravity | Breaking resistance (Kgf) | Percentage of shell(%) | Shell thickness (mm) |
| Hen | 1.091±0.003 | 4.438±0.581 | 9.574±0.503 | 0.387±0.019 |
| Quail | 1.072±0.005 | 1.441±0.312 | 8.056±0.586 | 0.207±0.019 |

**Table 2 -** Correlation analysis among specific gravity, egg breaking strength, shell percentage and eggshell thickness of semi-heavy hens.

| | Specific Gravity | Breaking resistance | Percentage of shell | Shell thickness |
|---|---|---|---|---|
| Specific gravity | - | 0.5074 | 0.5228 | 0.5751 |
| Breaking resistance | - | - | 0.5398 | 0.5271 |
| Percentage of shell | - | - | - | 0.5574 |

commercial laying hen farms for evaluation of eggshell quality, showed a higher correlation ($p < 0.05$) with eggshell thickness, which shows that the indirect measurement represents well the real conditions of structuration of eggshell thickness (Table 2). Taking into consideration that measurement by micrometer is one of the most sensitive methods, however, it detected values within good eggshell quality standards. Breaking strength presented lesser correlation ($p < 0.05$) with specific gravity, therefore, considering the sophistication, complexity and the high cost of this analysis, the measurement of specific gravity can be satisfactorily used instead.

The breaking strength parameter presented a higher relationship ($p < 0.05$) with the percentage of shell, corroborating the results of Molino et al. (2009), who in using the correlation analysis among the main analyses of hen eggshell quality, found a higher correlation of breaking strength with the percentage of eggshell regardless of the size of the probe used in the breaking strength equipment (2; 10 or 75 mm). Therefore, based on the results of the present study and the aforementioned literature, the breaking strength analysis seems to be more influenced by the shell concentration in relation to the other egg components (yolk and albumen) than by the shell thickness itself.

Regarding the shell percentage methodology, as expected, its highest correlation ($p < 0.05$) occurred with the shell thickness methodology, which proves that the structural proportion of eggshell deposited in the egg will determine its thickness.

There was no correlation ($p > 0.05$) between specific gravity and the other parameters of quail eggshell quality analysis (Table 3). One of the probable explanations for this result may be related to the fact that the specific gravity, when analyzed by the Archimedes principle, is obtained by the relation of egg weight and the weight of water displaced by it when completely submerged, having a direct correlation with its density as well as its amount of water. Therefore, considering that quail eggs have lower moisture content compared to hens, 71.7% versus 75.6% (TACO, 2011), and also concentrate, on average, lower values of shell and albumen percentage and higher yolk percentage, consequently present density different from that of hen eggs.

Another issue to be considered for the understanding of those results concerns the structural conditions hen and quail eggshells in relation to the organic matter content, which according to Pereira et al. (2009) is higher in hen eggshells, in addition in both species the calcium content in the shell is around 37% of the mass of this structure. In addition, the shell of quail eggs is thinner (SHANAWAY, 1994), but the thickness of the shell membranes in relation to the total shell volume is greater as compared with that of hen eggs, accounting for 21% of the total shell thickness, while in hen eggs, they represent 11% (BARBOSA et al., 2012; SANTOS et al., 2015).

**Table 3 -** Analysis of correlation among specific gravity, egg breaking strength, shell percentage and shell thickness in quail eggs.

| | Specific gravity | Breaking resistance | Percentage of shell | Shell thickness |
|---|---|---|---|---|
| Specific gravity | - | NS[1] | NS | NS |
| Breaking resistance | - | - | 0.6154 | NS |
| Porcentage of shell | - | - | - | 0.5836 |

[1]NS – non-significant for the Pearson Linear Correlation Linear analysis.

Thus, based on these results, the analysis of specific gravity by the methodology used in the present study may not be adequate for measuring the shell quality in eggs of this species, assuming the need to make saline solutions with densities different from those used for hen eggs.

For quail eggs, the correlation was positive (p <0.05) among the analysis of shell breaking strength with the percentage of the shell and with the shell thickness (Table 3), that correlation being higher for the percentage of shell. On the basis of these results, and on the probable unfeasibility of the specific gravity methodology for eggs of this species, as previously discussed, the parameter of shell percentage could be more viable in situations of impossibility or difficulty in adjusting the saline solutions used for the carrying out of the measurement of specific gravity for demanding lesser cost and only needs a scale to weigh the shells, besides time (on average 72 hours) for drying of them at room temperature, in cases where there is no availability of ventilated oven.

The highest degree of correlation (p <0.05) of the parameters of quail eggshell quality analysis occurred between breaking strength and shell percentage (Table 3), probably, because the percentage of shell in quail eggs is one of the lowest as compared with eggs of other poultry species (TOLIK et al., 2014). In spite of that, quail eggs present increased membrane thickness in relation to the total shell volume, and according to Santos et al. (2015), they are extremely elastic and resistant structures, which confer greater resistance to egg breaking in this species.

## CONCLUSION

The shell quality parameters analyzed: specific gravity, egg breaking strength, shell percentage and shell thickness in hen eggs presented a positive correlation to a moderate degree (0.54). For quail eggs, the percentage of shell shows moderate correspondence (0.60) only with breaking resistance and thickness of shell**,** since the specific gravity showed no correlation with the others, and based on these results, it follows that this method, using the same model applied to hen eggs, is not well suited for evaluating the quality of the shell in quail eggs, indicating the need for further research to test the need for a better adjustment of this methodology to make it more adapted to the morphology of quail eggs.

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