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SHORT COMMUNICATION



# Physical and chemical characteristics of eggs from eight Italian chicken breeds

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**ABSTRACT**

Specific characteristics of the eggs from nucleus populations of Ancona (AN), Bianca di Saluzzo (BS), Bionda Piemontese (BP), Livorno, Mericanel della Brianza (MB), Mugellese (MU), Siciliana (SI) and Valdarnese (VA) chicken breeds kept in University Research Centres across Italy were evaluated. The physical characteristics considered were whole egg weight and shell, yolk and albumen proportion. The chemical characteristics considered were dry matter (DM), ash and protein content of the yolk and albumen, and the yolk fat. Among the breed groups evaluated in this study, BS and BP produce large eggs that are rich in total crude protein and lipids, with abundant egg whites. MB and MU produce small eggs with a high yolk percentage. AN and SI hens produce medium-small-sized eggs. The heaviest yolks were observed in AN eggs, and the highest shell percentage was found in SI eggs. LB and VA produce medium-large-sized eggs with low yolk lipid content.

**HIGHLIGHTS**

- Basic information on the egg characteristics of some Italian local chicken breeds kept in University Research Centres across Italy.
- Expanding the dataset pertaining to the egg characteristics of diverse chicken breeds is essential for crafting a more accurate and comprehensive egg profile unique to each breed.
- Detailed knowledge about all aspects of local chicken breeds may help promote their use as well as maintain or even increase biodiversity.

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## Introduction

Greater levels of consumer awareness about environmental issues and the husbandry conditions to which commercial hybrids are exposed to are leading consumers to express ethical and welfare concerns about the poultry industry, and this is happening not only in Europe but also worldwide (Hammershøj et al. 2021). One consequence of these concerns has been the rapid growth in the organic egg market despite the associated higher production costs. Consumers are willing to pay even double the price for organic eggs with respect to conventional products (Franzoni et al. 2021; Hammershøj et al. 2021). Local breeds are particularly well-suited for this type of rearing system.

In this context, with the goal of valorising the characteristics of local breed products, this study reports specific egg quality traits of a sample of eggs from nucleus populations of eight Italian chicken breeds kept in University Research Centres situated across Italy.

## Materials and methods

### *Birds and management*

Animal handling was carried out in accordance with Italian Government guidelines (D.lgs 26/2014). The

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breeds evaluated were Ancona (AN), Bianca di Saluzzo (BS), Bionda Piemontese (BP), Livorno Bianca (LB), Mericanel della Brianza (MB), Mugellese (MU), Siciliana (SI) and Valdarnese (VA) (for detailed information on the morphology of each breed, please refer to TuBAvI Project (2023)). All hens were in their first productive cycle. All hens were offered the same commercial diet for local laying breeds, composed of 17% crude protein (CP) (%-as-fed-basis) and 11.8 MJ/kg of metabolisable energy. Hens were housed in poultry houses and all of them had free access to open-air runs.

### Sampling

The evaluated eggs, comprising 25 samples from each breed, were collected during the second week of May (refer to Table 1 for the age of each hen breed). Throughout this period, the daily temperature ranged from 11 °C to 24 °C when natural photoperiod was approximately 14 L:10D.

### Physical egg traits

Included the determination of the whole egg weight and the weight and percentage of the three main egg components (shell, yolk and albumen). After a 24 h storage period (12 °C and 55% humidity), whole eggs were individually weighed (Sartorius BL 150S, ± 0.001 g). Shelling and separation of the yolk from the albumen were done manually. The chalaza was cut and then the yolk was isolated from albumen residues by rolling it on blotting paper. The eggshell with its membranes and the cuticle were also cleaned of albumen residues and then dried inside a ventilated oven (50 °C for 3 h). The yolk weight was recorded, and the albumen weight was calculated ([egg weight − (yolk weight + dry eggshell weight)]). Albumen, yolk and shell percentages were calculated relative to the whole egg weight.

### Chemical analysis of egg components

Included the determination of dry matter (DM), ash and protein content in both the yolk and the albumen, as well as the total lipids in the yolk. Proximate analysis of egg yolks and albumens was performed following the procedures set out by the AOAC (2011). After the fresh weights were determined, albumen and yolk were lyophilised and subsequently weighed. The % DM of each component was calculated as (total lyophilised weight/total fresh weight) × 100. The albumen and yolk CP were determined (Kjeldahl copper catalyst method; conversion factor was 6.25) (AOAC 2011). The yolk ether extract (EE) was assessed (Tecator Soxtec System HT 1043 extractor unit, Foss Italia S.r.l.). The ash content was determined (samples subjected to 105 °C for 4 h, then 6 h at 550 °C).

### Statistical analysis

Wilcoxon/Kruskal–Wallis non-parametric tests were employed for non-normally distributed variables, otherwise a one-way ANOVA, followed by the Tukey's test, was used with the breed considered as the main factor. Data were analysed using JMP Statistical Discovery (SAS Institute Inc., Cary, NC, version 5.0.1).

## Results

### Distinctive hen traits and physical egg characteristics across breeds

The main characteristics of the hens from each breed in terms of body weight and yearly egg production are reported in Table 1 (TuBAvI Project 2023). Additionally, the table provides information on the weights of both whole eggs and their individual components.

Table 2 reports the egg component percentages relative to the whole egg weight and the yolk:albumen ratio. The eggs can be divided into two main groups with regard to egg yolk percentage: those for

**Table 1.** Productive traits of the hen breeds), age of hens at egg sampling, and weights of whole eggs and components (mean ± SD).

| Breed | AW[a] (g) | Eggs (n/year) | Age (weeks) | Egg[b] (g) | Yolk (g) | Albumen (g) | Shell (g) |
|---|---|---|---|---|---|---|---|
| Ancona | 1616 | 175 | 36 | 54.8 ± 3.0 | 19.6 ± 1.8 | 30.2 ± 1.7 | 5.0 ± 0.3 |
| Bianca di Saluzzo | 1850 | 150 | 50 | 62.2 ± 3.9 | 18.9 ± 1.6 | 36.4 ± 3.0 | 6.9 ± 0.6 |
| Bionda Piemontese | 1820 | 180 | 50 | 64.0 ± 3.8 | 19.0 ± 1.5 | 37.9 ± 3.0 | 7.1 ± 0.8 |
| Livorno Bianca | 1795 | 131 | 56 | 58.4 ± 3.0 | 18.2 ± 1.7 | 34.3 ± 2.2 | 5.9 ± 0.6 |
| Mericanel della Brianza | 600 | 72 | 50 | 35.5 ± 3.1 | 12.7 ± 1.0 | 19.7 ± 2.3 | 3.1 ± 0.3 |
| Mugellese | 740 | 110 | 50 | 31.8 ± 3.0 | 11.5 ± 1.1 | 16.7 ± 1.8 | 3.6 ± 0.6 |
| Siciliana | 1447 | 120 | 56 | 51.9 ± 3.3 | 15.9 ± 1.2 | 30.0 ± 2.4 | 6.0 ± 0.7 |
| Valdarnese | 1744 | 138 | 50 | 58.3 ± 3.9 | 17.5 ± 2.5 | 34.8 ± 2.6 | 6.0 ± 0.5 |

[a]AW = mean adult hen weight; [b]number of eggs per breed = 25.

Table 2. Egg components (% of whole egg weight) and yolk to albumen ratio (mean ± SD).

| Breed | Yolk | Albumen | Shell | Yolk:albumen |
|---|---|---|---|---|
| Ancona | 35.8 ± 2.0$^{A}$ | 55.2 ± 2.0$^{B}$ | 9.1 ± 0.6$^{D}$ | 0.65$^{A}$ |
| Bianca di Saluzzo | 30.4 ± 2.4$^{B}$ | 58.5 ± 2.4$^{A}$ | 11.0 ± 0.7$^{AB}$ | 0.52$^{B}$ |
| Bionda Piemontese | 29.8 ± 2.1$^{B}$ | 59.2 ± 2.1$^{A}$ | 11.1 ± 1.0$^{AB}$ | 0.50$^{B}$ |
| Livorno Bianca | 31.1 ± 2.5$^{B}$ | 58.8 ± 2.6$^{A}$ | 10.1 ± 0.7$^{C}$ | 0.53$^{B}$ |
| Mericanel della Brianza | 35.8 ± 2.4$^{A}$ | 55.4 ± 2.4$^{B}$ | 8.8 ± 0.9$^{D}$ | 0.65$^{A}$ |
| Mugellese | 36.3 ± 2.3$^{A}$ | 52.5 ± 2.2$^{C}$ | 11.2 ± 1.3$^{A}$ | 0.69$^{A}$ |
| Siciliana | 30.7 ± 1.9$^{B}$ | 57.7 ± 1.8$^{A}$ | 11.5 ± 1.3$^{A}$ | 0.53$^{B}$ |
| Valdarnese | 30.0 ± 3.5$^{B}$ | 59.7 ± 3.4$^{A}$ | 10.3 ± 0.8$^{BC}$ | 0.51$^{B}$ |

$^{A–D}$Means with different superscripts within a column are significantly different ($p < 0.01$).

Table 3. Chemical characteristics of the yolk (% of DM; mean ± SD).

| Breed | DM (% on fresh yolk)[a] | CP[b] | EE[c] | Ash |
|---|---|---|---|---|
| Ancona | 50.1 ± 1.0$^{AB}$ | 34.2 ± 0.8$^{A}$ | 56.0 ± 0.8$^{B}$ | 3.2 ± 0.2$^{BCD}$ |
| Bianca di Saluzzo | 50.7 ± 1.7$^{A}$ | 33.6 ± 0.9$^{A}$ | 56.4 ± 0.8$^{AB}$ | 3.0 ± 0.2$^{D}$ |
| Bionda Piemontese | 50.6 ± 1.5$^{A}$ | 33.5 ± 1.0$^{A}$ | 56.3 ± 0.9$^{AB}$ | 3.1 ± 0.2$^{CD}$ |
| Livorno Bianca | 50.1 ± 1.0$^{AB}$ | 34.1 ± 0.6$^{A}$ | 55.8 ± 0.9$^{B}$ | 3.3 ± 0.1$^{BC}$ |
| Mericanel della Brianza | 49.0 ± 1.1$^{C}$ | 34.2 ± 0.8$^{A}$ | 57.0 ± 1.0$^{A}$ | 3.2 ± 0.3$^{BCD}$ |
| Mugellese | 49.4 ± 1.4$^{BC}$ | 31.4 ± 2.7$^{B}$ | 56.9 ± 1.2$^{A}$ | 3.4 ± 0.4$^{B}$ |
| Siciliana | 50.4 ± 1.2$^{AB}$ | 33.7 ± 0.6$^{A}$ | 56.4 ± 0.8$^{AB}$ | 3.2 ± 0.2$^{BCD}$ |
| Valdarnese | 50.5 ± 1.3$^{AB}$ | 32.1 ± 2.0$^{B}$ | 55.7 ± 1.3$^{B}$ | 3.7 ± 0.3$^{A}$ |

[a]Dry matter; [b]crude protein; [c]ether extract; $^{A-D}$ means with different superscripts within a column are significantly different ($p < 0.01$).

Table 4. Chemical characteristics of albumen (% on DM; mean ± SD).

| Breed | DM (% on fresh albumen)[a] | CP[b] | Ash |
|---|---|---|---|
| Ancona | 11.9 ± 0.3$^{B}$ | 84.2 ± 0.8$^{AB}$ | 5.9 ± 0.3$^{BC}$ |
| Bianca di Saluzzo | 12.7 ± 0.4$^{A}$ | 84.4 ± 1.5$^{AB}$ | 6.0 ± 0.3$^{BC}$ |
| Bionda Piemontese | 12.6 ± 0.4$^{A}$ | 85.1 ± 0.9$^{A}$ | 6.1 ± 0.4$^{B}$ |
| Livorno Bianca | 11.2 ± 0.8$^{C}$ | 84.3 ± 1.1$^{AB}$ | 6.5 ± 0.5$^{A}$ |
| Mericanel della Brianza | 10.8 ± 0.5$^{CD}$ | 84.6 ± 1.2$^{AB}$ | 5.7 ± 0.3$^{CD}$ |
| Mugellese | 10.0 ± 0.8$^{E}$ | 83.7 ± 1.1$^{B}$ | 5.3 ± 0.5$^{E}$ |
| Siciliana | 10.5 ± 0.5$^{D}$ | 84.7 ± 1.2$^{AB}$ | 5.9 ± 0.4$^{BC}$ |
| Valdarnese | 10.8 ± 0.7$^{CD}$ | 83.9 ± 0.9$^{B}$ | 5.4 ± 0.4$^{DE}$ |

[a]Dry matter; [b]crude protein; $^{A–D}$ means with different superscripts within a column are significantly different ($p < 0.01$).

which yolk percentage was around 30% (BP, VA, BS, SI and LB), and those for which it was greater than 35% (MU, AN and MB; $p < 0.01$). The albumen percentage was inversely proportional to the yolk percentage, being most accentuated in MU eggs, which had the lowest albumen percentage ($p < 0.01$). The highest eggshell percentages were observed in SI, MU, BP and BS, and lowest values were found in MB and AN ($p < 0.01$). The yolk:albumen ratio was significantly higher in AN, MB and MU compared with all other breeds ($p < 0.01$).

### *Chemical egg characteristics*

The percentage of DM, CP, EE and ash in the egg yolks are reported in Table 3. The lowest DM content of yolk was detected in eggs from MB. The yolk CP percentage of VA and MU eggs was significantly lower than that of all the other breeds. The yolk EE percentage was higher in MB and MU eggs than in AN, VA and LB eggs. The yolk ash percentage was highest in VA eggs.

Results of the chemical analyses of the albumen are reported in Table 4. The lowest albumen DM percentage was observed in MU eggs. The albumen CP percentage of VA and MU eggs was statistically lower than that of BP eggs. Greater variation was found in the albumen ash percentage between breeds. The highest value was observed in LB eggs.

The nutritional properties of eggs are reported in Table 5. BP and BS eggs showed the highest CP:EE ratio, while the lowest ratio was observed in MU eggs.

## Discussion

It is essential to emphasise that this study was conducted on nucleus populations residing in different university centres across Italy. This posed challenges in implementing consistent breeding practices, encompassing factors such as food, hen age, season, and laying period. Additionally, the restricted number of eggs

**Table 5.** Total protein and lipid content (weight in g) and the protein to lipid ratio of eggs of mean weight according to chicken breed (mean ± SD).

| Breed | Total CP[a] (g) | Total EE[b] (g) | CP:EE |
|---|---|---|---|
| Ancona | 6.38 ± 0.39 | 5.49 ± 0.55 | 1.17 ± 0.08[DE] |
| Bianca di Saluzzo | 7.14 ± 0.53 | 5.41 ± 0.52 | 1.33 ± 0.10[AB] |
| Bionda Piemontese | 7.29 ± 0.48 | 5.42 ± 0.44 | 1.35 ± 0.09[A] |
| Livorno Bianca | 6.33 ± 0.37 | 5.08 ± 0.45 | 1.25 ± 0.08[BC] |
| Mericanel della Brianza | 3.94 ± 0.40 | 3.55 ± 0.32 | 1.11 ± 0.08[E] |
| Mugellese | 3.17 ± 0.27 | 3.24 ± 0.33 | 0.98 ± 0.08[F] |
| Siciliana | 5.38 ± 0.35 | 4.53 ± 0.36 | 1.19 ± 0.05[CDE] |
| Valdarnese | 5.99 ± 0.55 | 4.92 ± 0.79 | 1.24 ± 0.16[CD] |

[a]Crude protein; [b]ether extract; [A–F]means with different superscripts within a column are significantly different ($p < 0.01$).

available at any given time was influenced by the small populations maintained in each centre.

The literature available on egg weights is very limited, and the precise weight ranges for these breeds have not been clearly defined. In this study, the mean weight for AN eggs (54.7 g) might be considered representative based on the available data (55.4–57.4 g; Mugnai et al. 2014; 51.0 g TuBAvI Project 2023). The previously reported BS egg weights were 61.4 g according to Schiavone et al. (2009) and 53.4 g based on TuBAvI Project (2023). Therefore, the current mean is more closely aligned with the first value. The mean egg weight in BP was 62.2 g, which is closer to the 63.6 g of a second hen laying period (TuBAvI Project 2023). The egg weights for LB hens were previously reported to range from 55.4 to 60.0 g (Castellini et al. 2002), in accordance with 58.3 g in this study. MB eggs (35.6 g) were slightly heavier compared with previous studies which reported a mean value of 34.0 g (Cerolini et al. 2009; Marelli et al. 2020). The mean egg weight of MU (31.8 g) is comparable to previous reports (33.0 g; Minieri et al. 2016; 32.2 g; TuBAvI Project 2023; 31.9 g; Mannelli et al. 2023). The mean egg weight of 51.9 g in SI eggs may be considered representative based on previously reported values (54.9 g; Rosa Di et al. 2020; 50.3 g; TuBAvI Project 2023). The egg weight reported in Marelli et al. (2020) was 52.0 g for a sample of six VA eggs, while TuBAvI Project (2023) reports a mean egg weight of 56.3 g. The egg weight determined in our study (58.4 g) aligns more closely with the latter reported value.

Per EC regulation (EU, 2023), AN, LB, VA eggs fall in the medium size category (53-63 g); MB, MU, SI eggs are small (<53 g); BP, BS eggs are large (>63 g).

The yolk and albumen proportions are highly influenced by the genetic origin of birds (Nolte et al. 2021). The weight and percentage of the yolk in BS eggs in this study were identical to those in a previous report on eggs from 24 to 39-week-old hens, whereas the albumen percentage was higher (Schiavone et al. 2009). When considering the yolk percentage, the highest values were observed in eggs from the two bantam breeds (MB, MU) and AN hens (at approx. 36%), and a previous study of MB eggs even reported a value of 41% (Marelli et al. 2020), confirming the potential of this breed to produce eggs with a high yolk percentage. In the other Italian breeds, the yolk percentages were all above 30%, while data reported for the commercial lines is around 25% (Sirri et al. 2018; Kraus and Zita 2019).

The highest eggshell percentage observed here was for SI eggs at 11.5%, whereas previous data on eggs collected throughout the first productive cycle recorded a mean value of 13.7% (Rosa Di et al. 2020). For BS eggs, the eggshell percentage observed here was also lower than previous reports at 11.0 *vs.* 12.4% (Schiavone et al. 2009). In MB eggs, previous studies reported a value of 16.7% (Marelli et al. 2020), much greater than the 8.8% observed in this trial. The same authors reported 13.4% in VA eggs, while the value recorded here was 10.3%. These dissimilarities may, among other factors such as diet, temperature and age (Hammershøj et al. 2021), reflect differences in the evaluation methodology, particularly concerning MB eggs.

Slight differences in the weight and weight percentage of albumen were previously reported for eggs from different sources: AN (31.1–32.9 g; 54.9–57.8%; Mugnai et al. 2009), BS (34.9 g, 56.8% (Schiavone et al. 2009)), Livorno (31–33g; Castellini et al. 2002); 26.7 g, 55.4% (Rosa Di et al. 2020) and SI (29.54 g, 53.76%; Rosa Di et al. 2020). In contrast, MB (14.3 g, 42.1%) and VA (29.4 g, 56.6%) (Marelli et al. 2020) eggs exhibited different albumen values compared to those observed in this study (MB 19.7 g; 55.4%; VA 34.8 g; 59.7%). This difference is probably due to the different evaluation methodologies used. Another factor might be related to differences in egg weights between this and the previous study.

Previously reported values of yolk CP for BS, 32.2% (Schiavone et al. 2009), and SI, 33.2% (Rosa Di et al. 2020), agree with the observations of this study. For MU eggs, a range of 27–28% (Minieri et al. 2016; Mannelli et al. 2023) was reported, 3–4% less with respect to the value obtained in this trial. The yolk CP of LB eggs reported here agrees with the 34.0% reported previously (Rosa Di et al. 2020), but differs from the 29.4% reported by other authors (Minieri et al. 2016).

Small differences were observed in the albumen protein content between breeds. The protein content of the egg is highly influenced by the diet (Wang et al. 2017), and here all breeds were fed the same feed.

Previous data on the yolk fat content in eggs from MU, Livorno (Minieri et al. 2016) and BS (Schiavone et al. 2009) hens agree with those observed here. Recently, a slightly higher percentage (57.8%) was reported by Mannelli et al. (2023) in MU eggs compared with the 56.9% reported here. The SI (60.5%) and Livorno (61.5%) values reported by Rosa Di et al. (2020) were higher than those recorded here, probably related to differences in the origin of the hen strains.

The yolk ash content observed in this study varied slightly in LB (3.3%) with respect to the 3.7–3.9% previously reported (Minieri et al. 2016; Rosa Di et al. 2020). This was also the case for BS yolks: 3.0% *vs.* 3.4% (Schiavone et al. 2009). The yolk ash percentage in MU eggs (3.4%) agrees with other reports, which range from 3.3% to 3.5% (Minieri et al. 2016; Mannelli et al. 2023). The 4.6% yolk ash reported elsewhere for SI eggs (Rosa Di et al. 2020) is +1.4% higher than the value obtained in this study.

## Conclusions

Among the breed groups evaluated in this study, BS and BP produce large eggs with abundant egg whites, rich in total CP, and lipids. MB and MU produce small eggs with a high yolk percentage. AN and SI hens produce medium-small-sized eggs. The heaviest yolks were observed in AN eggs, and the highest shell percentage was found in SI eggs. LB and VA produce medium-large-sized eggs with low yolk lipid content.

These distinctive egg characteristics can enhance market options, empowering consumers with a broader food choice while simultaneously promoting the valorisation of local chicken breeds.

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## Ethical approval

Study exempts from ethical approval; conducted with eggs from Italian university research centres dedicated to poultry biodiversity preservation. No experimental procedures on laying hens; eggs collected during routine bird housing and management.

## Disclosure statement

No potential conflicts of interest are reported by the authors.

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## Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## References

AOAC. 2011. In: Herlich K, editor. Official methods of analysis of the Association of Official Analytical Chemists International. Arlington (VI). 2(34):853.

Castellini C, Perella F, Mugnai C, Dal Bosco A. 2002. Welfare, productivity, and qualitative traits of egg in laying hens reared under different rearing systems. Photochem Photobiol. 1804:9331.

Cerolini S, Madeddu M, Zaniboni L, Cassinelli C, Mangiagalli MG, Marelli SP. 2009. Breeding performance in the Italian chicken breed Mericanel della Brianza. Ital J Anim Sci. 9(4):e72. doi: 10.4081/ijas.2010.e72.

EU. Council of the European Union. Commission Delegated Regulation (EU) 2023/2465, Official Journals of the European Union, 2023. 32023:R2465

Franzoni A, Gariglio M, Castillo A, Soglia D, Sartore S, Buccioni A, Mannelli F, Cassandro M, Cendron F, Castellini

C, et al. 2021. Overview of native chicken breeds in Italy: small scale production and marketing. Animals (Basel). 11(3):629. doi: 10.3390/ani11030629.

Hammershøj M, Kristiansen GH, Steenfeldt S. 2021. Dual-purpose poultry in organic egg production and effects on egg quality parameters. Foods. 10(4):897. doi: 10.3390/foods10040897.

Kraus A, Zita L. 2019. The effect of age and genotype on quality of eggs in brown egg laying hybrids. Acta Univ Agric Silvic Mendelianae Brun. 67(2):407–414. doi: 10.11118/actaun201967020407.

Mannelli F, Franzoni A, Galigani I, Nistri V, Daghio M, Scicutella F, Marzoni M, Minieri S, Salvucci S, Cerolini S, et al. 2023. Characterization of morphological, reproductive, and productive performances of Mugellese breed: an update of knowledge. Poult Sci. 102(1):102259. doi: 10.1016/j.psj.2022.102259.

Marelli SP, Zaniboni L, Madeddu M, Sayed AA, Strillacci MG, Mangiagalli MG, Cerolini S. 2020. Physical parameters and fatty acids profiles in Milanino, Mericanel della Brianza, Valdarnese Bianca and commercial hybrids (*Gallus gallus domesticus*) table eggs. Animals (Basel). 10(9):1533. doi: 10.3390/ani10091533.

Minieri S, Buccioni A, Serra A, Galigani I, Pezzati A, Rapaccini S, Antongiovanni M. 2016. Nutritional characteristics and quality of eggs from laying hens fed on a diet supplemented with chestnut tannin extract (*Castanea sativa Miller*). Br Poult Sci. 57(6):824–832. doi: 10.1080/00071668.2016.1216944.

Mugnai C, Dal Bosco A, Castellini C. 2009. Effect of rearing system and season on the performance and egg characteristics of Ancona laying hens. Ital J Anim Sci. 8(2):175–188. doi: 10.4081/ijas.2009.175.

Mugnai C, Sossidou EN, Dal Bosco A, Ruggeri S, Mattioli S, Castellini C. 2014. The effects of husbandry system on the grass intake and egg nutritive characteristics of laying hens. J Sci Food Agric. 94(3):459–467. doi: 10.1002/jsfa.6269.

Nolte T, Jansen S, Weigend S, Moerlein D, Halle I, Simianer H, Sharifi AR. 2021. Genotypic and dietary effects on egg quality of local chicken breeds and their crosses fed with faba beans. Animals (Basel). 11(7):1947. doi: 10.3390/ani11071947.

Rosa Di AR, Chiofalo B, Lo Presti V, Chiofalo V, Liotta L. 2020. Egg quality from Siciliana and Livorno Italian autochthonous chicken breeds reared in organic system. Animals (Basel). 10(5):864. doi: 10.3390/ani10050864.

Schiavone A, Mellia E, Salamano G, Raccone V, Tarantola M, Nurisso S, Gennero S, Doglione L. 2009. Egg quality and blood parameters of "Bianca di Saluzzo" and ISA brown hens kept under free range conditions. Ital J Anim Sci. 8(2):772–774. doi: 10.4081/ijas.2009.s2.772.

Sirri F, Zampiga M, Soglia F, Meluzzi A, Cavani C, Petracci M. 2018. Quality characterization of eggs from Romagnola hens, an Italian local breed. Poult Sci. 97(11):4131–4136. doi: 10.3382/ps/pey275.

TuBAvI Project. 2023. Conservation of biodiversity in Italian poultry breeds. Fondo Europeo Agricolo per lo Sviluppo Rurale (FEASR) - MIPAAFT – Programma Sviluppo Rurale Nazionale 2014/2022. https://www.pollitaliani.it/en/

Wang X, Zhang H, Wang H, Wang J, Wu S, Qi G. 2017. Effect of dietary protein sources on production performance, egg quality, and plasma parameters of laying hens. Asian-Australas J Anim Sci. 30(3):400–409. doi: 10.5713/ajas.16.0457.