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Egg Quality and Nutritional Profile of Three Sicilian Autochthonous Chicken Breeds: Siciliana, Cornuta di Caltanissetta, and Valplatani

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Abstract: The conservation of native poultry breeds plays a strategic role in preserving biodiversity and promoting sustainable farming systems. In Sicily, Italy, the Siciliana breed has long been officially recognised as an autochthonous chicken breed, while the Cornuta di Caltanissetta and Valplatani breeds have only recently received official recognition. Traditionally reared under semi-extensive systems, these three breeds may produce eggs with valuable nutritional properties. This study aimed to evaluate the chemical composition, fatty acid profile, mineral content, and nutritional indices of eggs from these breeds. A total of 170 eggs were collected from 11 farms across three Sicilian provinces. Proximate analysis, cholesterol content, ICP-MS mineral profiling, and GC-FID fatty acid quantification were conducted following ISO and AOAC standards. Cornuta eggs showed significantly higher lipid and cholesterol content, but also a more favourable fatty acid composition, with higher levels of oleic acid (C18:1n9), lower saturated fatty acids, and improved health-related indices. Sodium levels were significantly lower in Cornuta eggs. No significant differences were found for total polyunsaturated fatty acids or the peroxidation index. The nutritional profile of Cornuta eggs supports their valorisation as a functional food, contributing to both human health and genetic conservation. These findings underscore the value of Sicilian native breeds—particularly Cornuta—as a sustainable resource for poultry production and the preservation of local agrobiodiversity.

Keywords: native chicken breeds; egg quality; biodiversity; fatty acids; nutrition

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1. Introduction

The conservation of autochthonous genetic resources is one of the most pressing challenges in sustainable agriculture, particularly in animal production. Local poultry breeds, shaped over centuries by natural adaptation to specific environmental and socio-cultural contexts, represent a unique reservoir of biodiversity. However, they currently face increasing threats from the expansion of commercial hybrids and ongoing genetic erosion [1,2].

In Sicily, a region with deep-rooted rural traditions, several historical poultry populations have been officially recognised as Italian native breeds. The Siciliana breed has long been included in the national registry, whereas the Cornuta di Caltanissetta (Ministry of Agriculture, Food Sovereignty and Forestry, Decree No. 0140687 of /03/27/2025) and Valplatani (MASAF Decree No. 184335 of 04/23/2024) breeds have only recently received official recognition. This recognition has enhanced their zootechnical relevance and opened new opportunities for both productive use and conservation-based valorisation [3]. Recent studies have confirmed the productive and qualitative potential of Italian local breeds reared under alternative systems, supporting their inclusion in national biodiversity protection programmes [4–6].

These breeds exhibit distinct phenotypic and morphological traits that may influence their adaptive capacity and egg quality [7]. The Siciliana, one of the oldest documented breeds in Italy (dating back to the 17th century), is characterised by a rose comb, golden or silver plumage, and a slender, upright body. It is valued for both egg-laying performance and ornamental features. The Cornuta di Caltanissetta, also known as Cornutella or Corna di Bue, originates from the hills and mountains of central Sicily and is notable for its bifid comb, wild-type plumage, and robust musculature. It displays considerable resistance to disease and environmental stress. The Valplatani, named after the Platani river valley in central-western Sicily, is compact in size, reddish in colour, and bears a single comb. It is typically reared in small-scale rural systems and is well adapted to marginal territories, with moderate laying capacity.

Genomic studies have confirmed the uniqueness of these populations. In particular, the Cornuta forms a distinct genetic cluster, whereas the Valplatani shows signs of admixture, possibly due to historical introgressions with commercial lines [8,9]. Morphological differences may also affect metabolic efficiency and reproductive traits. For example, the Cornuta's pronounced musculature may favour lipid deposition and influence yolk fatty acid composition, while the Valplatani's smaller size and rustic management may contribute to variability in nutrient assimilation. These hypotheses align with previous studies linking genotype, phenotype, and egg composition in native Italian breeds [4–6,9].

Sicilian poultry breeds therefore play a strategic role not only as genetic heritage to be preserved, but also as a sustainable resource for resilient, locally adapted farming systems. Their continued use supports rural development, biodiversity valorisation, and the creation of short food supply chains based on origin-certified products [1,2].

Eggs from native breeds are considered foods of high biological value, whose chemical and nutritional composition may reflect both genotype and environmental conditions. Several studies have shown that breed, diet, and farming system significantly influence egg quality traits, particularly lipid composition, fatty acid balance, and mineral profile [4–6].

In recent years, growing consumer awareness of nutrition, sustainability, and traceability has driven renewed interest in niche animal products with specific health-oriented characteristics. Eggs are widely recognised as a complete and affordable food, rich in high-quality proteins, bioavailable minerals, and essential lipids. Their nutritional profile is strongly influenced by genetic background and feeding conditions [1,4,6].

Autochthonous poultry breeds, long overlooked by commercial selection, are now increasingly valued for their capacity to produce functional animal-derived foods aligned with modern dietary models. Investigating the compositional and nutritional properties of their eggs may therefore contribute to strategies for biodiversity enhancement and health-based marketing models [2,5].

Within this framework, the present study aimed to assess the chemical composition, fatty acid profile, mineral content, and nutritional indices of eggs from three Sicilian native breeds—Siciliana, Cornuta di Caltanissetta, and Valplatani—highlighting breed-specific differences and identifying relevant traits for conservation and functional food development.

2. Materials and Methods

2.1. Sample Collection and Origin

A total of 170 eggs were collected from three Sicilian autochthonous chicken breeds—Siciliana, Cornuta di Caltanissetta, and Valplatani—registered in the Italian National Poultry Register. Sampling was conducted across 11 traditional farms located in 9 municipalities within the provinces of Caltanissetta, Agrigento, Siracusa, and Palermo (Sicily, Italy). Hens were reared under semi-extensive conditions with access to outdoor areas and were fed low-input, cereal-based diets composed mainly of locally grown grains (barley, wheat, and maize), without the use of synthetic additives or lipid-enriching supplements.

Each of the 170 eggs was individually labelled at the time of collection. Chemical and nutritional analyses were performed on a single-egg basis to preserve individual biological variability. Samples were stored at 4 °C and processed within 48 hours of arrival at the laboratory.

2.2. Chemical Analysis

Proximate Composition: Moisture, crude protein, total fat, and ash contents were determined using standard gravimetric and chemical procedures, following ISTISAN 1996/34 [10] and AOAC Official Method 994.10 [11].

Cholesterol Content: Cholesterol content was quantified using gas chromatography with flame ionisation detection (GC-FID), according to validated procedures described in previous studies [5].

Mineral Content: Mineral profiling was carried out using inductively coupled plasma mass spectrometry (ICP-MS) for the quantification of sodium (Na), potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu), selenium (Se), and manganese (Mn), following UNI EN ISO 17294-2:2016 [12].

Fatty Acid Profile: Total lipids were extracted from the yolks using a chloroform–methanol mixture (2:1, v/v). The lipids were then transmethylated to fatty acid methyl esters (FAMEs) using boron trifluoride (BF_3) in methanol and analysed by GC-FID using a 100 m CP-Sil 88 capillary column, according to ISO 12966-2:2017 [13] and Di Rosa et al. [5]. Identification of FAMEs was performed via retention time comparison with analytical standards, while quantification was based on internal calibration using tricosanoic acid (C23:0) as the internal standard.

2.3. Nutritional Indices

The following indices were calculated to evaluate the nutritional quality of the yolk lipid fraction:

Atherogenic Index (AI) and Thrombogenic Index (TI) as per Ulbricht and Southgate [14]:

$$AI = (C12{:}0 + 4 \times C14{:}0 + C16{:}0) / (\sum MUFA + \sum PUFA)$$

$$TI = (C14{:}0 + C16{:}0 + C18{:}0) / [0.5 \times \sum MUFA + 0.5 \times \sum n\text{-}6 + 3 \times \sum n\text{-}3 + (n\text{-}3/n\text{-}6)]$$

Hypocholesterolaemic/Hypercholesterolaemic Ratio (HH), according to Santos-Silva et al. [15]:

$$HH = (\sum C18{:}1 + \sum PUFA) / (C14{:}0 + C16{:}0)$$

Omega-6/Omega-3 ratio (n-6/n-3):

$$n\text{-}6/n\text{-}3 = \sum(n\text{-}6 \text{ fatty acids}) / \sum(n\text{-}3 \text{ fatty acids})$$

Peroxidation Index (PI), according to Arakawa and Sagai [16]:

$$PI = (0.025 \times \%monoenes) + (1 \times \%dienes) + (2 \times \%trienes) + (4 \times \%tetraenes) + (6 \times \%pentaenes) + (8 \times \%hexaenes)$$

2.4. Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) and the fixed effect of genetic type was evaluated using XLStat software (Addinsoft, 2025) [17].

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2.5. Language Editing Support

A professional version of ChatGPT (GPT-4, 2025) was used to support the preparation of this manuscript. The tool was employed exclusively to assist with language refinement, terminology consistency, and formatting in accordance with journal guidelines. All scientific content, data interpretation, and conclusions were entirely conceived, validated, and approved by the authors.

3. Results

The chemical composition of the eggs showed significant variation among the three Sicilian native breeds (Table.1). Cornuta eggs exhibited the highest average total lipid content in the egg (10.95 %), significantly exceeding the values observed in Siciliana (9.08 %) and Valplatani (10.33 %) eggs ($P < 0.05$). Cholesterol concentration followed a similar trend, with Cornuta yolks showing the highest values (1789 mg/100g yolk), indicative of increased lipogenic capacity. Previous studies have shown that dietary strategies can effectively reduce yolk cholesterol content [18]. No significant differences were found for protein and ash contents, whereas Siciliana eggs displayed a significantly higher moisture content compared to the other two breeds ($P < 0.05$).

Table 1. — Chemical and nutritional composition of eggs from three Sicilian chicken breeds.

Parameter	Siciliana (mean)	Cornuta (mean)	Valplatani (mean)	*P*-value
Energy (kJ/100 g)	545	616	596	ns
Moisture (%)	75.43^{a}	72.86^{b}	73.66^{ab}	<0.05
Fat (%)	9.08^{a}	10.95^{b}	10.33^{ab}	<0.05
Protein (%)	12.29	12.40	12.57	ns
Ash (%)	1.29	1.40	1.46	ns
Cholesterol (mg/100g yolk)	1464^{ac}	1789^{b}	1477^{ac}	<0.05
Salt (%)	0.33	0.33	0.35	ns

Mineral concentrations were generally consistent across the three groups (Table 2). However, sodium levels were significantly lower in Cornuta eggs ($P < 0.05$), suggesting breed-specific physiological mechanisms in electrolyte regulation or deposition. The levels of potassium, calcium, magnesium, and trace minerals (iron, zinc, selenium) were similar among breeds and fell within the expected range for table eggs.

Table 2. – Mineral composition (mg/100 g of edible egg) from three Sicilian chicken breeds.

Element	Siciliana (mean)	Cornuta (mean)	Valplatani (mean)	*P*-value
Sodium	133.54^{a}	133.20^{a}	139.92^{b}	<0.05
Potassium	142.60	141.33	143.98	ns
Phosphorus	216.10	219.36	224.24	ns
Calcium	58.03	58.35	59.44	ns
Magnesium	12.55	12.58	12.34	ns
Iron	2.55	2.63	2.19	ns
Zinc	1.23	1.27	1.26	ns
Copper	0.16	0.08	0.10	ns
Selenium	0.01	0.01	0.01	ns
Manganese	0.04	0.04	0.04	ns

The fatty acid profile revealed pronounced breed-related differences (Table 3). Cornuta eggs had a significantly lower proportion of saturated fatty acids (SFA) and a higher content of monounsaturated fatty acids (MUFA), especially oleic acid (C18:1n9), in comparison to Siciliana and Valplatani ($P < 0.05$). The oleic acid content in Cornuta reached 50.74 %, compared to 39.92 % in

Siciliana and 43.36 % in Valplatani. Conversely, palmitic acid (C16:0) was significantly lower in Cornuta, supporting a more favourable lipid profile for human health.

No significant differences were observed for total polyunsaturated fatty acids (PUFA); however, Cornuta eggs had higher levels of nutritionally relevant omega-3 fatty acids, particularly alpha-linolenic acid (C18:3n-3) and eicosapentaenoic acid (C20:5n-3). This resulted in a more desirable omega-6/omega-3 ratio in Cornuta eggs (7.35), approaching values recommended for human nutrition.

Table 3. – Fatty acid profile and acidic classes (%) of yolk from three Sicilian chicken breeds.

Fatty Acid (%)	**Siciliana** (mean)	**Cornuta** (mean)	**Valplatani** (mean)	***P*-value**
C14:0	1.10[a]	0.95[b]	1.02[a]	<0.05
C16:0	37.19[a]	28.31[b]	34.79[a]	<0.05
C18:0	10.52	9.29	9.88	ns
C18:1 n-9	39.92[a]	50.74[b]	43.36[a]	<0.05
C18:2 n-6	8.40[a]	6.58[b]	7.95[a]	<0.05
C18:3 n-3	0.63[a]	0.90[b]	0.68[a]	<0.05
C20:4 n-6	1.45	1.21	1.34	ns
C20:5 n-3	0.21[a]	0.41[b]	0.31[a]	<0.05
SFA	48.81[a]	38.55[b]	45.92[a]	<0.05
MUFA	48.16[a]	56.22[b]	48.16[a]	<0.05
PUFA	6.40	5.03	5.84	ns
Omega 3	6.18	4.45	5.32	ns
Omega 6	0.49	0.61	0.54	ns

Nutritional indices further confirmed the superior profile of Cornuta eggs (Table 4). The atherogenic index (AI) and thrombogenic index (TI) were significantly lower (AI: 0.52; TI: 1.22), while the hypocholesterolaemic/hypercholesterolaemic ratio (HH) was significantly higher (2.02) compared to the other two breeds ($P < 0.05$). The peroxidation index (PI) did not differ significantly among breeds, indicating similar oxidative stability of yolk lipids.

Table 4. – Nutritional indices of yolk from three Sicilian chicken breeds.

Index	**Siciliana**	**Cornuta**	**Valplatani**	***P*-value**
n-6/n-3	13.21[a]	7.35[b]	12.34[a]	<0.05
AI	0.82[a]	0.52[b]	0.72[a]	<0.05
TI	1.91[a]	1.22[b]	1.66[a]	<0.05
HH	1.30[a]	2.02[b]	1.44[a]	<0.05
PI	25.1	24.8	25.0	ns

4. Discussion

Eggs from the three Sicilian local chicken breeds—Cornuta, Siciliana, and Valplatani—exhibited distinctive lipid and nutritional profiles, reflecting interactions between genetic heritage and environmental conditions.

Fatty Acids and Nutritional Indices Cornuta eggs exhibited the highest levels of total lipids and cholesterol. While these values may raise nutritional concerns, they should be interpreted in the context of the overall lipid profile. Cornuta eggs were characterized by a high proportion of monounsaturated fatty acids (MUFA), particularly oleic acid (C18:1n9), and polyunsaturated fatty acids (PUFA), especially alpha-linolenic acid (C18:3n-3), a precursor of long-chain omega-3 fatty acids. These compounds are recognized for their cardioprotective, lipid-modulating, and anti-inflammatory properties [19].

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The nutritional indices—atherogenic index (AI), thrombogenic index (TI), and hypocholesterolaemic/hypercholesterolaemic ratio (HH)—further support the favourable lipid quality of Cornuta eggs. Compared with the other breeds, Cornuta eggs exhibited significantly lower AI and TI and higher HH values, suggesting a reduced cardiovascular risk and improved nutritional benefit [12,13,20].

These differences may reflect physiological mechanisms involved in hepatic lipid metabolism. In laying hens, the liver is the main site for fatty acid synthesis destined for yolk deposition. Key enzymes include acetyl-CoA carboxylase (ACC), fatty acid synthase (FAS), and stearoyl-CoA desaturase (SCD1). Enhanced SCD1 expression in Cornuta hens may contribute to increased MUFA synthesis. Additionally, elevated activity of Δ6- and Δ5-desaturase enzymes could explain the higher eicosapentaenoic acid (EPA) levels observed [16,21].

The peroxidation index (PI), which estimates lipid susceptibility to oxidative degradation, showed no significant differences among breeds. This suggests effective endogenous antioxidant defences, potentially supported by tocopherols, carotenoids, and selenium-dependent enzymes [22,23]. Semi-extensive rearing conditions, including access to vegetation rich in antioxidant compounds, may further enhance redox balance [14,23,24].

Mineral Content Cornuta eggs also showed significantly lower sodium concentrations, which may reflect breed-specific physiological mechanisms involving intestinal absorption, renal regulation, and ion transport in the eggshell gland [25,26]. From a dietary perspective, lower sodium levels are advantageous for individuals adhering to low-sodium regimens and may influence the sensory and technological characteristics of eggs.

The overall mineral composition was consistent across breeds, with sodium as the only significant exception. This suggests a general uniformity in mineral deposition, coupled with unique breed-related traits.

Although management conditions and cereal-based diets were similar across farms, genotype × environment interactions likely influenced the observed differences [27–30]. Cornuta hens may possess greater efficiency in feed conversion and yolk nutrient allocation. Access to spontaneous vegetation—such as legumes, brassicaceous plants, and aromatic herbs—could have increased the levels of beneficial fatty acids and antioxidants [31,32]. This reflects the "terroir effect", where local ecology and rustic genotype interact to shape product quality [5].

These results highlight the nutritional value of Cornuta eggs as products of genetic heritage and environmental synergy. Cornuta eggs exhibited a particularly favourable lipid profile, especially regarding MUFA content (56.22%) and the n-6/n-3 ratio (7.35), both superior compared to commercial hybrid eggs (Hy-Line and Warren), where average MUFA values range between 40% and 49%, and n-6/n-3 ratios are around 12–16, depending on the diet [33]. The other native Sicilian breeds analysed, Valplatani and Siciliana, although showing a lower MUFA content (48.16% for both), presented values comparable or competitive with those of commercial eggs.

Regarding the nutritional indices, Cornuta showed a particularly interesting profile. Compared to the values reported for Hy-Line and Warren hybrid eggs (AI ~1–1.5; TI ~2–3), Cornuta displayed lower atherogenic (AI 0.52) and thrombogenic (TI 1.22) indices, indicating higher lipid quality [33]. However, when compared to Isa Brown eggs reported by Dedousi et al. [34] (AI ≈ 0.43–0.53; TI ≈ 0.38–0.78), Cornuta eggs showed slightly higher AI and TI values, while maintaining a hypocholesterolemic/hypercholesterolemic ratio (HH 2.02) in line with that observed in commercial products. Valplatani (AI 0.72; TI 1.66; HH 1.44) and Siciliana (AI 0.82; TI 1.91; HH 1.30) showed less favourable indices compared to both Cornuta and the commercial references, confirming the central role of genetic background and diet in determining the nutritional quality of eggs.

Within a framework of moderate and regular consumption—e.g., one egg per day—Cornuta eggs may serve as valuable dietary sources of omega-3 fatty acids and MUFA. Their lipid profile, together with their genetic and environmental specificity, underlines their potential as functional foods. As consumers increasingly favour natural, local, and health-promoting products, these eggs could be effectively positioned through voluntary labelling schemes such as "biodiversity-sourced" or "functional egg" [35].

Supporting the conservation and production of these breeds aligns with broader objectives in sustainability, public health, and agricultural diversification. Cornuta represents a model for how natural selection, environmental adaptation, and low-input systems can yield nutritionally superior animal products.

Integration into niche food chains—supported by origin-based claims and nutritional valorization—may thus represent a sustainable strategy for promoting Sicilian poultry biodiversity. This approach complements contemporary goals in agroecology, nutrition, and genetic conservation [2,35,36].

5. Conclusions

The Siciliana, Cornuta di Caltanissetta, and Valplatani chicken breeds represent a strategic genetic resource for promoting more sustainable, diversified, and locally rooted food systems. This study provides the first comprehensive nutritional characterization of their eggs under semi-extensive conditions. The findings confirm distinct breed-related differences and support the productive and nutritional valorization of these autochthonous populations [2,4].

In particular, Cornuta eggs stood out for their favourable lipid profile, including higher levels of monounsaturated fatty acids (MUFA), a more balanced omega-6/omega-3 ratio, and improved nutritional indices (AI, TI, HH), indicating superior lipid quality. As the birds were managed under similar environmental and dietary conditions, these differences reflect the intrinsic genetic influence on egg composition. This evidence positions these native breeds as ideal candidates for alternative production models based on quality, authenticity, and sustainability [2,3,36].

From a conservation perspective, the results contribute to active genetic preservation efforts by demonstrating that poultry biodiversity is not only a cultural asset but also a biological resource with measurable impact on food quality [1,37]. These findings can inform national and regional programs for in situ conservation, integrating productivity and sustainability objectives [35].

Nutritional and compositional attributes may also be leveraged for market differentiation. Product labelling schemes focused on breed origin or natural lipid profiles can support consumer recognition and niche marketing strategies centered on health, sustainability, and territorial identity [5].

On a territorial level, the rearing of native poultry breeds can support rural development strategies by contributing to short food supply chains, food tourism, and community-based agroecology. These animals may become drivers of value in marginal areas, fostering innovation in harmony with conservation [3–5].

Cultural and educational efforts aimed at disseminating the role of animal biodiversity in nutrition could also benefit from these results. Integrating such content into school curricula, outreach activities, and food strategies may improve consumer awareness and nutritional literacy [1,2].

Finally, these data may serve as a scientific basis for policy actions supporting the inclusion of native breeds in quality schemes, agri-environmental payments, and dietary guidelines. This integration of nutritional quality, genetic conservation, and territorial sustainability aligns with the FAO Global Plan of Action for Animal Genetic Resources [38], the EU Farm to Fork Strategy [39], and the United Nations 2030 Agenda for Sustainable Development [40].

In conclusion, detailed nutritional characterization of eggs from Sicilian native breeds offers a concrete pathway to support poultry biodiversity. These breeds are not merely remnants of the past, but a vital opportunity to shape a healthier, more resilient, and sustainable future of food.

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