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Evaluation of breast meat quality in slow-growing native chickens compared with commercial medium- and fast-growing hybrids

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ABSTRACT

The recent consumer interest in native poultry breeds has increased, driven by perceptions of their high quality, thus contributing to the preservation of local genetic resources. This study investigated the chemical, texture, and sensory traits of breast meat from three slow-growing Italian chicken breeds (Bionda Piemontese [BP], Bianca di Saluzzo [BS], Millefiori Piemontese [MP]) and compared them with those for medium- and fast-growing commercial hybrids (Naked Neck [NN] and Ross 308 [BR]). The studies were performed on 15 samples per genotype, and included chemical composition, thawing (TL) and cooking losses (CL), texture profile analysis (TPA) on cooked meat, Warner-Bratzler shear force test (SFT), and sensory evaluation by trained judges. Slaughter weight was higher in MP than in BP and BS ($p = 0.039$). Breast weight was greater in BR compared with NN and the native breeds (on average, +72 %; $p < 0.001$). Moisture was highest in BR and lowest in NN, with native breeds showing intermediate values (80.1-68.6 %; $p < 0.001$). Ash content was higher in native breeds and NN than in BR ($p < 0.001$). NN showed the highest crude protein percentage (25.7 %), followed by the native breeds (on average, 24.8 %) and BR (15.9 %; $p < 0.001$). No differences were observed in lipids. The highest and lowest TL and CL were recorded for BR and BS, respectively (5.24 and 2.83 %; 17.2 and 12.5 %; $p < 0.001$). TPA revealed greater hardness, adhesiveness, cohesiveness, chewiness, and gumminess in breast meat of local breeds than in commercial hybrids (on average, +50.1 %). SFT values were higher in native breeds than commercial hybrids, underlining their greater firmness (on average, +33.9 %; $p < 0.001$). Sensory evaluation confirmed the tougher consistency ($p = 0.002$) and lower fibrousness ($p = 0.006$) and mealiness ($p = 0.020$) in native breeds. BR showed greater overall and typical odor ($p < 0.05$). Greasiness and freshness were higher in BR ($p = 0.025$ and $p = 0.007$, respectively). Adhesiveness was greater in NN ($p < 0.001$). Metallic flavor was more intense in BS and MP ($p = 0.009$). These findings highlight the distinctive properties of Italian native breeds, underscoring the importance of their conservation.

Introduction

Consumer demand for poultry meat continues to rise, mainly due to its competitive production costs associated with its short rearing cycles and high nutritional value (OECD-FAO, 2021). In recent decades, the intensification of livestock farming systems has progressively favored the use of highly productive commercial hybrids, which have been specifically selected over slower-growing traditional breeds due to their fast growth and high feed efficiency (Castillo et al., 2021). This transition has brought substantial benefits in terms of productivity and cost-effectiveness, but it has also resulted in the erosion of genetic diversity. Consequently, the loss of genetic resources has become a critical issue, with significant impact on local traditions, rural economies, and long-term sustainability (Dabbou et al., 2022). Unlike commercial lines, local breeds are not subjected to intense selection, and they are valued for their resilience and adaptability to local environments (Zanetti et al.,

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2010a). For this reason, they are most often reared in extensive, low-input systems. In Italy, the Ministry of Agriculture, Food Sovereignty and Forests recognizes 26 native chicken breeds (D.M. n. 014687, 01/04/2025), 19 of which are currently under conservation programs. The region of Piedmont (in northwest Italy) is home to three of those 26 native dual-purpose breeds: Bionda Piemontese (BP), Bianca di Saluzzo (BS), and Millefiori Piemontese (MP). These breeds present unique characteristics for which they are widely appreciated in Italy: the capon of the BP breed is highly valued (Castillo et al., 2021); BS is a registered Slow Food presidium (Slow Food, 2024); and MP was once greatly valued for its delicate meat until the industrialization of livestock farming led to its decline (Castillo et al., 2021; Tutela della Biodiversità nelle Razze Avicole Italiane TuBAvI 2025). The MP population decreased so sharply that it was considered extinct in the 1990s (Cappone et al., 2025a). However, thanks to the discovery of a few MP subjects in southern Piedmont, the breed has been successfully recovered, and continuing efforts are being made to reintroduce it (Stoppani et al., 2024). These three breeds are classified as endangered, slow-growing, dual-purpose chickens. The common slaughter age for native breeds is between five and six months of age (Bongiorno et al., 2022). In contrast, commercial hybrids are slaughtered between 35 and 81 days of age and are heavily selected for their higher breast yield (Tixier-Boichard, 2020).

In recent years, native poultry breeds have been increasingly recognized for their potential to meet the growing demand for high-quality and niche animal products, for which they are gaining popularity among consumers (Franzoni et al., 2021; Del Bosque et al., 2021). This trend might be due to the fact that consumers perceive products from local poultry breeds as superior in terms of their sustainability, nutritional quality, and organoleptic properties (Cappone et al., 2025b). Previous studies confirm that the nutritional composition and technological traits of meat from commercial lines differ from those from autochthonous breeds (Cassandro et al., 2015; Huerta et al., 2023); however, there is still limited information in the literature regarding the meat quality of native slow-growing chicken breeds, and only a few direct comparisons with commercial medium- and fast-growing chicken hybrids have been made. The purpose of this study was to assess the quality attributes of breast meat from the above-mentioned slow--growing native breeds, namely BP, BS, and MP, and to compare them with those from commercially available medium- and fast-growing chicken hybrids.

Materials and methods

Birds and husbandry

The experimental protocol (Prot. No. 0544534 of 23/09/2024) was approved by the Bioethical Committee of the University of Turin. All methods are reported in accordance with ARRIVE guidelines for the reporting of animal experiments. The trial was conducted at the Avian Conservation Centre for the Valorization of Local Genetic Resources (CoVaGEN) of the University of Turin, Italy. For this study, as reported by Cappone et al. (2025c), 160 males (60 BP, 60 BS, and 40 MP) aged 29 days were allocated to pens according to breed (10 birds/pen; 6 replicates for BP and BS, and 4 replicates for MP). The reduced number of MP was due to the limited availability of eggs for incubation, highlighting the importance of conserving and valorizing this breed. Each pen measured 6 $m \times 1.5\ m \times 3$ m ($l \times w \times h$) and rice hulls was used as litter. The experimental facility was subjected to natural environmental conditions. The trial was performed from May to November 2023 and the average monthly temperatures ranged from 12 °C in November to 28 °C in July. Relative humidity ranged from 60 % in July to 75 % in October. Finally, photoperiod ranged from 15 h of natural daylight in June to 9.5 h in November. Birds were provided *ad libitum* water and a commercial corn–soybean meal–based feed (Fratelli Borello S.p.A., Bra, Cuneo, Italy), administered in three phases: from day 1 to 28 (AMEn: 12.5 MJ/kg; CP: 22.0 %, as fed), from day 29 to 84 (AMEn: 12.8 MJ/kg; CP: 20.5 %, as fed), and from day 85 to 182 (AMEn: 13.3 MJ/kg; CP: 18.0 %, as fed). At 182 days of age, all birds were individually weighed (slaughter weight: SW) and 15 males per breed were selected, based on the average body weight of the respective breed, and slaughtered by stunning and bleeding. Carcasses were plucked, eviscerated, and weighed (KERN PLE-N v. 2.2, Kern&Sohn, Balingen-Frommern, Germany; d: 0.1) to assess the ready-to-cook carcass weight (RTCC). Thereafter, pectoralis major muscles were separated from the whole carcass, weighed, vacuum-sealed, and stored at −20 °C. For comparison, two commercial hybrids were also included, sourced from local butchers: the medium-growing Naked Neck (NN), slaughtered at 90 days of age, and the fast-growing Ross 308 broiler (BR), slaughtered around 30 days of age. For each genotype, 15 pectoralis major muscles ($n = 75$) were sampled and processed under the same storage conditions for further analyses.

Physical and technological properties

After 24 h of refrigeration at 4 °C, pHu and color were evaluated on the left caudal side of the breast muscle. Specifically, the pHu was measured using a pH meter equipped with an electrode designed for meat penetration (Crison, Crison Instruments, SA, Alella, Spain), while the brightness (L*), redness (a*), and yellowness (b*) color indexes were assessed using a portable Chroma Meter CR-400 colorimeter with an 8 mm measuring area, D65 illuminant, 10° standard observer (Konica Minolta Sensing Inc., Osaka, Japan).

To evaluate the thawing loss, the left portion of the cranial section of each breast muscle was individually vacuum-packed and stored at −20 °C. Breast samples were then thawed at 4 °C, removed from the bags, gently dried with absorbent paper, and weighed. The thawing loss was calculated as follows.

$$\textit{Thawing loss}\left(\mathrm{TL},\%\right)=\left\{\frac{\mathrm{FreshRawBreastWeight(g)}-\mathrm{ThawedBreastWeight(g)}}{\mathrm{FreshRawBreastWeight(g)}}\right\}\times 100$$

Thereafter, the meat samples were vacuum-sealed and heated in a water bath at 80 °C for 45 minutes, to ensure that the sample had reached 75 °C at its core. We used a probe thermometer (HD 9219; Delta OHM, Caselle Di Selvazzano [PD], Italy) to verify the internal temperature. The meat samples were cooled in fresh water for 10 minutes to reach room temperature, then removed from the bags, gently dried with absorbent paper, and weighed to assess the cooking loss, which was calculated as follows.

$$\textit{Cooking loss}\left(\mathrm{CL},\%\right)=\left\{\frac{\mathrm{ThawedBreastWeight(g)}-\mathrm{CookedBreastWeight(g)}}{\mathrm{ThawedBreastWeight(g)}}\right\}\times 100$$

From these, we calculated the total water losses as follows:

$$Total\ losses\left(\mathrm{TotL},\%\right)=\left\{\frac{\mathrm{FreshRawBreastWeight(g)}-\mathrm{CookedBreastWeight(g)}}{\mathrm{FreshRawBreastWeight(g)}}\right\}\times 100$$

Chemical composition

The nutritional parameters of breast samples were analyzed according to the guidelines provided by the Association of Official Analytical Chemists (AOAC, 2004). The analyses were conducted on the caudal portion of freeze-dried breast muscle to determine moisture content (MC; #950.46) and ash content (AC; #920.153). CP was assessed using the Kjeldahl method (#2001.11) and ether extract (EE) content was determined through Soxhlet extraction using petroleum ether, in accordance with AOAC method #991.36 (2000). Chemical composition results are reported as grams per 100 grams of fresh matter and, by consequence, the moisture to protein ratio was assessed as grams of H_2O per gram of CP.

Textural and organoleptic properties

The texture profile analysis (TPA) was performed on the cooked left portion of the cranial section of each breast muscle, after cooking loss assessment. The test was carried out using a TA.HDplus Texture Analyzer (Stable Micro Systems Ltd., England). The method involves two successive compression cycles using a flat probe (P/10; Stable Micro Systems Ltd., England) of diameter (Ø) 10 mm. The samples were compressed to 50 % of their height at a rate of 3.33 mm/s; a pause of ten seconds was established between the two cycles of compression. Each sample was subjected to the two rounds of compression in two different spots. The TPA measured the following parameters: hardness (N), springiness, adhesiveness (N·s), cohesiveness, chewiness (N), and gumminess (N).

The Warner Bratzler shear force test (SFT) was performed on the cooked breast samples used to assess the cooking loss, using a TA.HDplus Texture Analyzer (Stable Micro Systems Ltd., England). From each sample, two rectangular 1 cm^2 blocks were taken parallel to the muscle fibers and sheared perpendicularly to the longitudinal axis using a USDA Standard Warner-Bratzler Blade Set (HDP/WBV; Stable Micro Systems Ltd., England). The speed of the V-shaped blade was set to 3.33 mm/s. The parameters measured were shear force (N) and firmness (N·s).

The left caudal portion of each breast muscle was individually vacuum-packed and stored at −20 °C, then thawed at 4 °C for 24 h. The breasts samples were cooked sous-vide at 80 °C for 45 minutes to an internal temperature of 75 °C, then cooled in cold water for 20 minutes. Each sample was cut into homogenous portions and given to ten judges (aged 30–50 years) trained in sensory descriptive analysis. The sensory evaluation was conducted according to the standard protocol UNI, 8589:1990, in individual booths with tablets equipped with a specific software for sensory data acquisition (FIZZ Biosystèmes, France). The evaluation was performed in duplicate, in compliance with the standard ISO, 13299:2016 for descriptive analysis, using intensity scales from 1 (hardly perceptible) to 9 (very intense) for each of the 25 evaluated sensory attributes (ISO, 8586:2012). The attributes evaluated in this study are reported in detail in Fiorilla et al. (2024), based on the existing literature, and all judges were familiar with their assessment. Specifically, the sensory traits evaluated were overall odor, typical odor, plant odor, off-odor, consistency, fibrousness, mealiness, greasiness, adhesiveness, juiciness, chewiness, astringency, pungency, sweetness, saltiness, sourness, bitterness, umami taste, overall flavor, typical flavor, plant flavor, metallic flavor, wild animal flavor, off-flavor, and freshness. Samples were given a random three-digit code and presented randomly to judges, who were provided with mineral water to cleanse their mouth between samples.

Statistical analysis

Data were analyzed using IBM SPSS Statistics (version 29.0.2.0). The assumptions of the statistical analyses were first tested: the normality of the distributions was determined using the Shapiro-Wilk test ($p > 0.05$) and the homogeneity of variance was tested using the Brown-Forsythe test ($p < 0.05$). To analyze the meat quality traits, a General Linear Model (GLM) was employed. The fixed factors included genotype and sample source (experimental vs butcher). For sensory evaluation parameters, a Linear Mixed Model (LMM) was performed, including genotype and panelist as fixed and random factors, respectively. Degrees of freedom were estimated using the Satterthwaite approximation and robust standard errors were computed using the HC3 heteroskedasticity-consistent estimator to account for potential violations of model assumptions. When significant differences were detected, Tukey's HSD was employed and, if a higher test power was required to detect marginal differences among groups, the Duncan multiple range test was additionally applied. The results are presented as least square means (LSM) and standard error of mean (SEM). The relationship between chemical composition, water losses, and qualitative parameters was assessed using Spearman's rank correlation coefficient ρ ($-1 < \rho < 1$). Statistical significance was set at $p < 0.05$.

Results

Physical and technological properties

The comparison of SW, RTCC, and breast muscle weights are presented in Table 1. In terms of SW, MP was the heaviest breed, followed by BP and BS (3242, 3034, and 2912 g, respectively; $p = 0.039$). No differences were observed among the three native breeds for RTCC. The heaviest breast muscle weight was recorded for BR (540 g), followed by NN (353 g) and MP (346 g), BP (298 g), and BS (259 g; $p < 0.001$).

Table 1
Mean slaughter weight at 182 days of age (g), ready-to-cook carcass yield (% SW), and weight (g) of the pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

Breed	SW	RTCC	Pectoralis major weight
BP	3034^{b}	66.9	298^{bc}
BS	2912^{b}	65.0	259^{c}
MP	3242^{a}	65.6	346^{b}
NN	-	-	353^{b}
BR	-	-	540^{a}
SEM	88.86	0.978	15.03
p-value	0.039	0.374	<0.001

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *SW*: slaughter weight; *RTCC*: ready-to-cook carcass; *SEM*: standard error of the mean.

Table 2
pHu and color of the pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

Breed	pHu	L*	a*	b*
BP	5.74^{b}	47.50^{c}	0.33^{c}	12.42^{ab}
BS	5.81^{b}	47.53^{c}	0.32^{c}	10.45^{b}
MP	5.76^{b}	48.56^{c}	−0.87^{d}	12.78^{a}
NN	5.74^{b}	55.00^{b}	1.47^{b}	4.72^{c}
BR	6.01^{a}	58.28^{a}	2.70^{a}	4.70^{c}
SEM	0.034	0.645	0.254	0.507
p-value	<0.001	0.004	<0.001	0.010

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *L**: brightness; *a**: redness; *b**: yellowness; *SEM*: standard error of the mean.

Table 3
Thawing, cooking, and total losses (%) of the pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

Breed	Thawing loss	Cooking loss	Total losses
BP	4.24^{a}	13.1^{b}	16.8^{b}
BS	2.83^{b}	12.5^{b}	15.0^{b}
MP	3.87^{ab}	13.0^{b}	16.4^{b}
NN	3.95^{ab}	13.9^{b}	17.3^{b}
BR	5.24^{a}	17.2^{a}	21.5^{a}
SEM	0.355	0.461	0.614
p-value	0.003	<0.001	<0.001

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *SEM*: standard error of the mean.

The breast pHu and color results are shown in Table 2. As concerns pHu, BR presented the highest value (6.01), followed by BS, MP, BP and NN (5.81, 5.76, 5.74, and 5.74, respectively; $p < 0.001$). Regarding L*, BR had the lightest breast meat (58.28) followed by NN (55.00), then MP, BS, and BP (48.56, 47.53, and 47.50, respectively; $p = 0.004$). BR also presented the highest a* value (2.70), followed by NN (1.47), then BP, BS, and MP (0.33, 0.32, and −0.87, respectively; $p < 0.001$), whereas b* values were lowest in NN (4.72) and BR (4.70) followed by BS (10.45), BP (12.42) and MP (12.78; $p = 0.010$).

Results regarding water losses are shown in Table 3. The genotype presenting the highest TL values was BR (5.24 %) followed by BP (4.24 %), NN (3.95 %), MP (3.87 %), and BS (2.83 %; $p = 0.003$). For CL, BR presented the highest score (17.2 %) compared to the other genotypes (13.9, 13.1, 13.0 and 12.5 % for NN, BP, MP and BS, respectively; $p < 0.001$). The same pattern was recorded for TotL, where BR reported the highest values (21.5 %), followed by NN, BP, MP, and BS (17.3, 16.8, 16.4 and 15.0 %, respectively; $p < 0.001$).

Chemical composition

The results for the breast chemical composition are presented in Table 4. The lowest moisture content value was revealed for NN (68.6 %), followed by BS, BP and MP (71.1, 71.4, 72.1 %), then BR (80.1 %; $p < 0.001$). The highest ash content was observed in BS (1.44 %), followed by NN, MP, BP (1.31, 1.26, and 1.18 %, respectively) then BR (0.92 %; $p < 0.001$). Crude protein was higher in the native breeds (25.2 % for BS, 24.9 % for BP, 24.4 % for MP) and NN (25.7 %) compared with BR (15.9 %; $p < 0.001$). No differences were observed in ether extract. Moisture to crude protein ratio was notably higher in BR (5.33) than MP (2.96), BP (2.82), NN (2.81) and BS (2.80; $p < 0.001$).

Textural and organoleptic properties

The TPA of breast meat showed that genotype did not influence springiness (Table 5). The lowest hardness values were observed in NN (22.7 N) and BR (27.7 N), followed by BP (31.5 N), MP (31.6 N) and BS

Table 6
Warner Bratzler shear force test (SFT) on cooked pectoralis major muscle of Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

Breed	Shear force (N)	Firmness (N·s)
BP	23.8^{a}	5.77^{a}
BS	21.4^{a}	5.73^{a}
MP	24.1^{a}	6.10^{a}
NN	17.1^{b}	4.19^{b}
BR	17.5^{b}	4.00^{b}
SEM	1.251	0.344
p-value	<0.001	<0.001

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *SEM*: standard error of the mean.

Table 4
Chemical composition (% fresh matter) and moisture to crude protein ratio of the pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

Breed	Moisture	Ash content	Crude protein	Ether extract	Moisture/crude protein
BP	71.4^{b}	1.18^{b}	24.9^{a}	0.80	2.82^{b}
BS	71.1^{b}	1.44^{a}	25.2^{a}	0.95	2.80^{b}
MP	72.1^{b}	1.26^{ab}	24.4^{a}	0.90	2.96^{b}
NN	68.6^{b}	1.31^{ab}	25.7^{a}	0.89	2.81^{b}
BR	80.1^{a}	0.92^{c}	15.9^{b}	1.06	5.33^{a}
SEM	0.925	0.052	0.710	0.107	0.197
p-value	<0.001	<0.001	<0.001	0.530	<0.001

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *SEM*: standard error of the mean.

Table 5
Texture profile analysis (TPA) on cooked pectoralis major muscle of Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler.

Breed	Hardness (N)	Springiness	Adhesiveness (N·s)	Cohesiveness	Chewiness (N)	Gumminess (N)
BP	31.5^{a}	0.89	−0.75^{ab}	0.62^{a}	17.3^{a}	19.4^{a}
BS	32.3^{a}	0.90	−1.58^{a}	0.62^{a}	18.1^{a}	20.2^{a}
MP	31.6^{a}	0.90	−1.62^{a}	0.59^{a}	17.0^{a}	18.6^{a}
NN	22.7^{b}	0.92	−1.09^{ab}	0.51^{b}	10.7^{b}	11.6^{b}
BR	27.7^{ab}	0.90	−0.59^{b}	0.47^{b}	11.7^{b}	13.1^{b}
SEM	1.657	0.016	0.290	0.012	0.903	1.016
p-value	<0.001	0.804	0.040	0.020	<0.001	<0.001

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *SEM*: standard error of the mean.

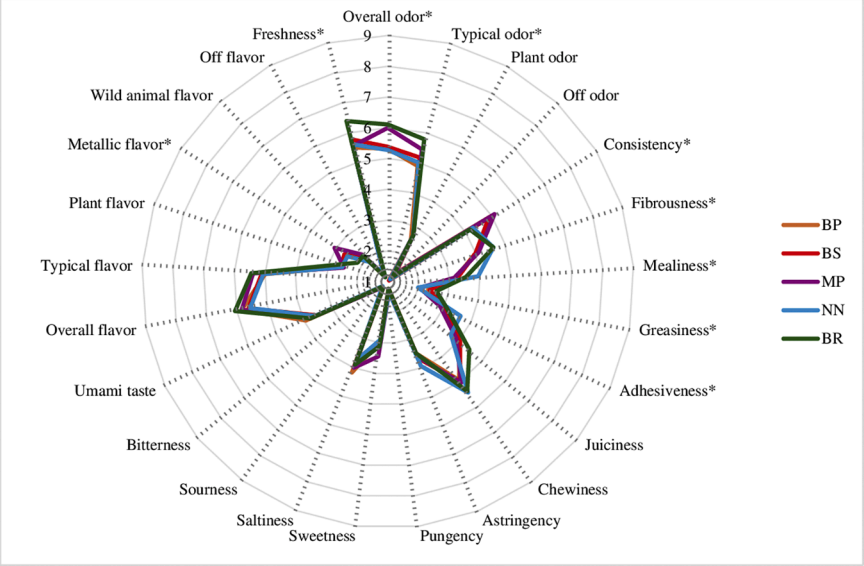

Fig. 1. Sensory evaluation results of cooked pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.
BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *: $p < 0.05$; *SEM*: standard error of the mean.

Table 7
Sensory evaluation results of cooked pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

	BP	BS	MP	NN	BR	SEM	p-value
Overall odor	5.78^{ab}	5.56^{b}	6.22^{a}	5.44^{b}	6.22^{a}	0.218	0.004
Typical odor	5.22^{b}	5.33^{b}	5.78^{ab}	5.22^{b}	6.11^{a}	0.296	0.037
Plant odor	2.56	3.11	3.11	3.00	3.11	0.283	0.162
Off odor	1.67	1.11	1.44	1.22	1.44	0.174	0.099
Consistency	5.33^{a}	5.11^{a}	5.33^{a}	4.56^{b}	4.44^{b}	0.206	0.002
Fibrousness	4.33^{b}	4.22^{b}	4.56^{b}	5.00^{a}	5.00^{a}	0.288	0.006
Mealiness	3.67^{b}	3.67^{b}	3.44^{b}	4.44^{a}	4.00^{a}	0.226	0.020
Greasiness	2.78^{b}	2.78^{b}	2.33^{b}	2.22^{b}	3.00^{a}	0.310	0.025
Adhesiveness	3.22^{b}	3.33^{b}	3.11^{b}	4.11^{a}	3.44^{b}	0.277	<0.001
Juiciness	4.44	4.44	4.22	4.22	4.89	0.327	0.412
Chewiness	5.11	5.33	5.33	5.78	5.67	0.271	0.174
Astringency	3.78	4.22	4.00	4.44	3.78	0.217	0.064
Pungency	1.56	1.33	1.44	1.44	1.33	0.188	0.497
Sweetness	3.11	3.22	3.56	3.11	3.22	0.253	0.093
Saltiness	4.22	4.00	4.22	4.11	4.11	0.320	0.910
Sourness	1.44	1.33	1.33	1.44	1.33	0.170	0.580
Bitterness	1.22	1.22	1.44	1.22	1.33	0.189	0.168
Umami taste	4.11	3.89	4.00	3.89	4.11	0.305	0.855
Overall flavor	6.11	5.89	6.22	5.78	6.33	0.229	0.187
Typical flavor	5.33	5.33	5.78	5.33	5.67	0.305	0.323
Plant flavor	2.89	3.00	2.89	2.78	3.00	0.313	0.915
Metallic flavor	3.00^{b}	3.11^{a}	3.44^{a}	2.67^{b}	2.56^{c}	0.243	0.009
Wild animal flavor	2.22	2.44	2.56	2.00	2.33	0.357	0.302
Off flavor	1.33	1.22	1.33	1.44	1.33	0.165	0.667
Freshness	5.56^{c}	6.00^{ab}	5.89^{bc}	5.89^{bc}	6.89^{a}	0.353	0.007

BP: Bionda Piemontese; *BS*: Bianca di Saluzzo; *MP*: Millefiori Piemontese; *NN*: Naked Neck; *BR*: Ross 308; *SEM*: standard error of the mean.

(32.3 N; $p < 0.001$). Among the evaluated genotypes, MP and BS presented greater adhesiveness (−1.62 and −1.58 N·s, respectively) than NN (−1.09 N·s), BP (−0.75 N·s) and BR (−0.59 N·s; $p = 0.040$). Cohesiveness, chewiness and gumminess were greater in BS (0.62, 18.1 N, and 20.2 N, respectively), BP (0.62, 17.3 N, and 19.4 N, respectively) and MP (0.59, 17.0 N, and 18.6 N, respectively) than in NN (0.51, 10.7 N, and 11.6 N, respectively) and BR (0.47, 11.7 N, and 13.1 N, respectively; $p = 0.020$, $p < 0.001$ and $p < 0.001$, respectively).

SFT results revealed higher values in autochthonous breeds compared with commercial hybrids (Table 6), with MP and BP requiring the most intense cutting strength (24.1 and 23.8 N, respectively), followed by BS (21.4 N), BR (17.5 N), and finally NN (17.1 N; $p < 0.001$). The same trend was observed for firmness with MP, BP, and BS showing the higher values (6.10, 5.77, and 5.73 N·s, respectively), followed by NN (4.19 N·s) and BR (4.00 N·s; $p < 0.001$).

Breast sensory evaluation revealed differences across nine of the attributes (Fig. 1 and Table 7). Overall odor was more intense in BR and MP (6.22) than in BP (5.78), BS (5.56), and NN (5.44; $p = 0.004$). The typical chicken meat odor followed a similar trend, with the highest value in BR (6.11), followed by MP (5.78), BS (5.33), NN and BP (5.22; $p = 0.037$). As concerns the texture, greater values for consistency were attributed to the native breeds (5.33, 5.33 and 5.11 for MP, BP, and BS, respectively) than in NN and BR (4.56 and 4.44, respectively; $p = 0.002$). Fibrousness was more relevant in BR and NN (5.00) compared with MP (4.56), BP (4.33) and BS (4.22; $p = 0.006$). Mealiness was more pronounced in NN and BR (4.44 and 4.00, respectively) than in BP, BS

Table 8
Spearman's rank correlation coefficients (ρ) among different qualitative parameters of cooked pectoralis major from Bionda Piemontese, Bianca di Saluzzo, Millefiori Piemontese, Naked Neck, and Ross 308 broiler chickens.

	W	MC	AC	CP	TL	CL	TotL	Ha	Ad	Co	Ch	Gu	SF	Fi
W	-													
MC	**0.60**	-												
AC	**−0.54**	**−0.73**	-											
CP	**−0.62**	**−0.95**	**−0.74**	-										
TL	**0.27**	**0.25**	−0.17	−0.22	-									
CL	**0.42**	**0.32**	**−0.28**	**−0.31**	**0.45**	-								
TotL	**0.45**	**0.37**	**−0.29**	**−0.35**	**0.77**	**0.89**	-							
Ha	**0.38**	−0.21	0.20	**0.23**	0.12	−0.01	0.01	-						
Ad	−0.02	**−0.24**	0.06	**0.24**	0.07	0.05	0.05	0.05	-					
Co	**−0.65**	**−0.46**	**0.41**	**0.47**	**−0.31**	**−0.41**	**−0.44**	**0.43**	**0.13**	-				
Ch	**−0.53**	**−0.33**	**0.31**	**0.34**	−0.05	−0.19	−0.19	**0.90**	0.04	**0.72**	-			
Gu	**−0.51**	**−0.31**	**0.26**	**0.33**	0.00	−0.14	−0.13	**0.94**	0.12	**0.69**	**0.97**	-		
SF	**−0.25**	−0.22	0.17	0.22	0.11	−0.10	−0.03	**0.56**	−0.12	**0.46**	**0.55**	**0.56**	-	
Fi	**−0.41**	**−0.32**	**0.25**	**0.30**	0.17	−0.17	−0.07	**0.53**	−0.05	**0.46**	**0.54**	**0.55**	**0.80**	-

Statistically significant correlations are shown in bold ($p < 0.05$). W: breast weight (g); MC: moisture content; AC: ash content; CP: crude protein; TL: thawing loss (%); CL: cooking loss (%); TotL: total water losses (%); Ha: hardness (N); Ad: adhesiveness (N·s); Co: cohesiveness; Ch: chewiness (N); Gu: gumminess (N); SF: shear force (N); Fi: firmness (N·s).

and MP (3.67, 3.67, and 3.44, respectively; $p = 0.020$). Greasiness was higher in BR (3.00) than BP and BS (2.78), MP (2.33) and NN (2.22; $p = 0.025$). Adhesiveness was higher in NN (4.11), followed by BR (3.44), BS (3.33), BP (3.22) and MP (3.11; $p < 0.001$). MP and BS were characterized by the most intense metallic flavor (3.44 and 3.11, respectively) compared with BP (3.00), NN (2.67), and BR (2.56; $p = 0.009$). Finally, for what concerns freshness, BR presented higher values (6.89) than BS (6.00), NN (5.89), MP (5.89) and BP (5.56; $p = 0.007$).

Results for Spearman's rank correlation analysis are available in Table 8. MC was negatively correlated with AC ($\rho = -0.73$; $p < 0.001$), CP ($\rho = -0.95$; $p < 0.001$), adhesiveness ($\rho = -0.24$; $p = 0.042$), cohesiveness ($\rho = -0.46$; $p < 0.001$), chewiness ($\rho = -0.33$; $p = 0.004$), gumminess ($\rho = -0.31$; $p = 0.007$), and firmness ($\rho = -0.32$; $p = 0.005$). MC presented positive correlations with breast weight ($\rho = 0.60$; $p < 0.001$), TL ($\rho = 0.25$; $p = 0.034$), CL ($\rho = 0.32$; $p = 0.005$), and TotL ($\rho = 0.37$; $p = 0.001$). No correlations were found between MC and hardness and shear force.

Discussion

The aim of the present study was to compare the quality of the breast meat from three native slow-growing chicken breeds with that of commercial medium- and fast-growing hybrids in order to emphasize the potential to valorize meat products from autochthonous genetic resources in niche and high-value markets. While no data are available on MP, previous studies that focused on the carcass characteristics of other slow-growing Piedmontese breeds reported the birds to have lower SW than those observed in the present work. For example, in Bongiorno et al. (2022) the average SW of 6 months old male BP and BS were 2188 and 2260 g, respectively. Interestingly, these results do not comply with those of the present study, in which SW was on average +4.19 % higher for BP than for BS (3034 g for BP and 2912 g for BS). Furthermore, Bongiorno et al. (2022) observed lower breast muscle weights for BP and BS between 5 and 8 months of age (231 and 233 g, respectively) compared with those evaluated in the present study (298 g for BP and 259 g for BS). Fiorilla et al. (2024) also reported a lower SW for BS aged 174 days (2480 g), as well as lower breast weights (232 g) compared to those observed in our study. The birds analyzed by Bongiorno et al. (2022) and Fiorilla et al. (2024) belong to earlier generations that are genetically related to those examined in our study, thus indicating that the differences observed across these studies provide indirect evidence of the genetic progress achieved in recent years. Specifically, the higher yields recorded in the present study for BP and BS indicate that the selection strategies implemented within these populations have been effective in improving productive performance. Regarding the commercial hybrids, breast muscle weights of NN reported in the literature ranged from 267 g (Sirri et al., 2011) to 422 g (Dal Bosco et al., 2014), and the mean value observed in the present study (353 g) falls withing this interval. Similarly, regarding the fast-growing BR, breast muscle weights ranged from 496 g (Biasato et al., 2025) to 560 g (Huerta et al., 2023), with the mean value obtained in our work representing an intermediate position within this range (540 g). The pH values observed for BR in the present study were slightly above the commonly accepted normal range for chicken breast meat (5.8-6.0). For instance, Tasoniero et al. (2019) reported an average pH of 5.99 in normal chicken breasts, which slightly differs from our results (6.01). Elevated pH values in broiler breast meat have been frequently associated with muscle abnormalities such as white striping and wooden breast (Soglia et al., 2016; Baldi et al., 2020; Barbut et al., 2024). Although these myopathies were not specifically assessed in the present study, the observed combination of lower CP, higher MC and reduced water-holding capacity could contribute to the higher pH values detected. By contrast, the three native breeds presented more acidic pH values, lower L*, and higher b* values. Bongiorno et al. (2022) observed slightly higher pH values in BP and BS (5.91 and 5.88, respectively), but different color values (L*, a*, and b* for BP: 51.22, 1.89 and 8.62, respectively; L*, a*, and b* for BS: 51.13, 1.40, and 8.10, respectively). Finally, Fiorilla et al. (2024) observed similar pH values (5.72) and higher L* values (51.90) in 174-day-old BS, while a* and b* were lower than in those evaluated in the present study (0.14 and 7.47, respectively). The increased L* values recorded in our work for the two faster-growing genotypes are consistent with findings reported in studies available in the literature, which typically exhibit lighter breast meat color due to lower myoglobin concentrations and a higher incidence of myopathies (Baldi et al., 2019). Several studies have also indicated that L* values tend to increase as pH rises (Tasoniero et al., 2019; Baldi et al., 2020), supporting the relationship between these parameters. Furthermore, the higher breast yield observed in fast-growing genotypes could also influence pH, resulting in slightly elevated values (Petracci et al., 2015). Predictably, BR showed the highest TotL compared with the other observed genotypes. Fast-growing broilers have generally been reported to show TL values ranging from about 6.52 to 10.7 % (Pellattiero et al., 2020 and Biasato et al., 2025, respectively), with CL values spanning from 16.8 to over 41.3 % (Biasato et al., 2025 and Huerta et al., 2023), and an average TotL of 35.8 % (Pellattiero et al., 2020). Regarding native breeds, Huerta et al. (2023) reported significantly higher CL from breast meat of 99-day-old BP compared with the present study (33.1 %), and the 174-day-old BS evaluated by Fiorilla et al. (2024) showed similar TL values (2.66 %). Interestingly, the Italian slow-growing Milanino breed, studied by Mosca et al. (2018), was characterized by lower CL values at

180 d (10.2 %), although the MC was similar to that of the breeds in the present study (72.4 %). By contrast, the 190-day-old Padovana, Ermellinata, and Pepoi native chicken breeds evaluated by Zanetti et al. (2010b) showed greater CL values (18.2, 19.3, and 22.3 %, respectively) than those found in the breeds evaluated in the present study. The birds were also characterized by a higher MC content (75.1, 73.8, and 74.5 %, respectively) than the autochthonous breeds evaluated here.

Regarding chemical composition, in the present study, CP was remarkably higher in the slow- and medium-growing genotypes than in the fast-growing one. Bongiorno et al. (2022) reported similar CP values in BP and BS between five and eight months of age (25.0 and 25.6 %, respectively). Fiorilla et al. (2024) also recorded similar values in BS slaughtered at 174 d (24.9 %). Furthermore, some studies have compared fast-growing broilers with medium- and slow-growing genotypes and found similar CP contents (Castellini et al., 2002; Dal Bosco et al., 2014). In contrast, Huerta et al. (2023) evaluated the chemical composition of breast meat of 99-day-old BP and 42-day-old BR and observed statistically significant differences between the two genotypes for CP (24.3 and 19.2 %, respectively). Although muscle degenerations were not directly evaluated in our work, the pattern of lower CP and higher MC, pH and water losses aligns with characteristics typically reported for breast meat from fast-growing commercial hybrids. Comparable crude protein values have been reported by Fanatico et al. (2007). It is well known that age influences the chemical composition of meat; as animals get older, protein and fat contents tend to increase, while moisture decreases (Fanatico et al., 2007; Sirri et al., 2011). Furthermore, BR showed the highest MC compared with the other evaluated genotypes. Interestingly, NN showed the lowest MC value among the evaluated genotypes. That said, Dal Bosco et al. (2014) reported higher MC values for NN breast meat, although their birds were slaughtered at a younger age (22.9 and 23.3 % at 70 and 81 d, respectively) than done here. Thus, although NN is considered a medium-growing genotype, its breast meat MC content was slightly lower than that of MP, which is a slow-growing breed. Bongiorno et al. (2022) reported slightly higher MC in BP and BS between 5 and 8 months of age (74.3 and 74.2 %, respectively). Huerta et al. (2023) observed similar values in BP slaughtered at 99 d (73.8 %). In contrast, Fiorilla et al. (2024) reported lower MC in BS slaughtered at 174 d (66.2 %). These results are supported by numerous studies which show the water content in meat to decrease with age (Baéza et al., 2012; Dal Bosco et al., 2014). The MC/CP ratio is widely recognized as an important indicator of meat quality, as it reflects the balance between moisture content and the protein fraction of the muscle, therefore lower values are preferable (Dias et al., 2020). To provide an overview of this parameter, we calculated the MC/CP ratio based on a thorough review of the literature, even though these values were not explicitly reported by the original authors. Compared with the present study, similar MC/CP values were reported by Bongiorno et al. (2022) in BP and BS (2.98 and 2.90, respectively), whereas Fiorilla et al. (2024) observed lower values in BS slaughtered at 174 d (2.66). Dal Bosco et al. (2014) found higher MC/CP values in NN compared with those observed in the present work (3.72 vs 2.81), whereas Huerta et al. (2023) reported lower ratios in BR than those evaluated in our study (4.04 vs 5.33). Indeed, the Spearman's rank correlations supported these observations, as MC, AC, and CP were correlated with one another, with CP representing a major component of the solid fraction of muscle tissue (Xiong, 2018). Furthermore, meat moisture and water losses are tightly correlated (Barbut, 2024), as corroborated by the Spearman's rank correlation coefficients obtained here (MC and TL, ρ=0.25; MC and cooking losses CL, ρ= 0.32; MC and TotL, ρ=0.37). Furthermore, chemical composition and water holding capacity directly influence the technological quality of meat, as do genotype, age, and locomotor activity (Pellattiero et al., 2020). In the present study, the breast meat from the native breeds was tougher than that from the medium- and fast-growing hybrids: hardness, chewiness, and gumminess were all significantly higher, influencing cohesiveness, and adhesiveness. Predictably, the SFT and firmness values for meat from the native breeds were higher than for NN and BR. Although Fiorilla et al. (2024) observed lower SFT values in 174-day-old BS, values in native slow-growing breeds are generally higher than in faster-growing ones (Huerta et al., 2023). Nevertheless, other studies reported lower SFT in autochthonous slow-growing breeds, namely, 180-day-old Milanino (Mosca et al., 2018) and 190-day-old Padovana, Ermellinata, and Pepoi (Zanetti et al., 2010b). Other studies that focused on slow-growing genotypes reported lower SFT than the present study in younger birds (Mueller et al., 2018), although the maximal shear force was higher than that in younger, fast-growing genotypes. Li et al. (2019) observed that SFT increased with age in a local Chinese breed, ranging from 19.3 N at 60 d to 38.9 N at 180 d. These results further underline the influence of age on meat tenderness within the same genotype, which tends to decrease as birds age (Fletcher, 2002; Mir et al., 2017). Therefore, texture-related parameters were correlated with MC in cooked meat, suggesting that muscles with lower moisture are associated with a firmer structure, resulting in enhanced mechanical resistance during mastication (Bulgaru et al., 2022). Instrumental texture profiles were confirmed by trained judges, and the breast meat of the three autochthonous breeds were characterized by greater consistency compared with the two commercial hybrids evaluated. As reported above, Pellattiero et al. (2020) observed commercial fast-growing hybrids to present more tender meat compared with slow-growing native breeds, while Huerta et al. (2023) found no differences. Interestingly, Fanatico et al. (2006) observed tougher consistencies in medium-growing hybrids compared with both slow- and fast-growing ones, whereas the present study could not discriminate between BR and NN. The same trend was observed for mealiness and fibrousness, with the native breeds presenting, according to the trained judges, a finer texture than NN and BR. Instrumental measurements of adhesiveness did not align with the sensory evaluation results, with trained judges perceiving greater and lower adhesiveness in NN and MP, respectively. This discrepancy between instrumental and descriptive measurements is not uncommon. Although instrumental measurements are objective, they do not take into consideration the multiple factors that humans experience while eating (Foegeding et al., 2011). Furthermore, sensory perception integrates multiple factors, such as saliva interaction, temperature, sample cut, therefore the amount of connective tissue or intramuscular fat (Bourne, 1975; Chen and Opara, 2013; Choi et al., 2019). This might also explain the perceived difference in greasiness among genotypes by trained panelists, although results for EE were not statistically significant. In the present study, both overall and typical odors were perceived as more intense in BR than in the medium- and slow-growing genotypes. These findings contrast with previous reports, which generally associated stronger aroma profiles with older birds and slower-growing strains (Wang et al., 2024). A possible explanation for this discrepancy might be that fast-growing genotypes are characterized by a lower content of endogenous antioxidants, which may accelerate the oxidative degeneration of polyunsaturated fatty acids, therefore enhance the formation of volatile compounds responsible for odor perception (Cartoni Mancinelli et al., 2021). It should also be noted that the BR samples evaluated in the present study were sourced from a commercial butcher, which might have influenced their oxidative status and, consequently, the odor profile observed. Nevertheless, BR presented higher freshness values compared with the other genotypes, suggesting that genotype-related differences in oxidative stability could play a key role in shaping the sensory attributes of poultry meat. Finally, the incidence of perceived metallic taste is mainly linked to two factors: the presence of inosine 5′-monophosphate (IMP) and heme iron (Aliani and Farmer, 2005; Pellattiero et al., 2020). Although the quantification of these two components was not performed in the present study, IMP is considered one of the major nucleotides that influences the flavor of cooked meat (Xu and Yin, 2024), and several studies have shown that its concentration in meat is strongly influenced by age and genotype, thus being higher in slow-growing breeds (Jayasena et al., 2015; Xiao et al., 2021).

Furthermore, other studies support the hypothesis that slow-growing breeds present higher heme iron content than fast-growing hybrids (Dal Bosco et al., 2014; Pellattiero et al., 2020). This phenomenon is mainly due to the fact that slow-growing breeds are reared in extensive systems, allowing birds to engage in more intense locomotor activity, contrary to fast-growing hybrids, which are limited by smaller roaming areas in intensive indoor systems and encounter greater physical challenges due to their unbalanced muscle and skeletal growth ratio (Campbell et al., 2017; Lambertz et al., 2018). Finally, the distinctive organoleptic characteristics observed in local breeds underline the need for targeted communication strategies and *ad hoc* culinary approaches to compliment the uniqueness and versatility of these products within both traditional and modern gastronomic contexts.

The present study highlighted the influence of genotype and age on the chemical composition, technological properties and sensory profile of chicken breast meat. Overall, native slow-growing breeds presented compositional and textural traits distinct from fast-growing hybrids, confirming the impact of slower growth rates and longer rearing periods on meat quality characteristics. Medium-growing genotypes generally exhibited intermediate values, although some overlapping trends with fast-growing broilers were observed. Beyond their productive performance, the preservation and valorization of local genetic resources are fundamental to safeguard poultry biodiversity and to promote meat products with distinctive quality attributes. Further studies are needed to fully explore the meat quality and the productive potential of autochthonous breeds, to both deepen our understanding of their superior nutritional and technological traits and to promote their preservation as a valuable genetic resource for biodiversity and as a sustainable alternative to commercial hybrids.

Declarations

Ethical Approval

The experimental protocol (Prot. No. 0544534 of 23/09/2024) was approved by the Bioethical Committee of the University of Turin. All methods are reported in accordance with ARRIVE guidelines for the reporting of animal experiments.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available upon request.

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Eleonora Erika Cappone: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alberto Brugiapaglia:** Writing – review & editing, Investigation. **Jacopo Pio Salvatico:** Investigation. **Edoardo Fiorilla:** Writing – review & editing, Investigation. **Valeria Zambotto:** Investigation. **Chiara Bianchi:** Investigation. **Giulia Maria Daniele:** Writing – review & editing, Investigation. **Marta Cianciabella:** Writing – review & editing, Investigation. **Stefano Predieri:** Writing – review & editing, Investigation. **Kalliopi Rantsiou:** Writing – review & editing, Funding acquisition. **Achille Schiavone:** Writing – review & editing, Visualization, Methodology, Investigation, Funding acquisition, Conceptualization.

Disclosures

All the authors declare that there is no financial/personal interest or belief that affect their objectivity.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psj.2025.106133.

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Further reading

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