Livestock Science 306 (2026) 105923

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Quality and composition of the *Branca* breed cock meat fed with maize or concentrate

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HIGHLIGHTS

- Bird feed minimally affects pH but muscle type differences are significant.
- Thighs retain more moisture, fat, and lipids than breasts, which are protein-rich.
- Maize feed boosts SFA/MUFA; concentrates enhance healthful PUFAs like EPA and DHA.
- Diet and muscle type interplay shapes meat's nutritional and physicochemical traits.

ARTICLE INFO

Keywords:
Branca chicken breed
Concentrate
Breast
Diet
Fatty acids
Poultry
Thigh
Maize
Meat

ABSTRACT

This study investigates the chemical and physical properties of *Branca* chicken meat, a traditional Portuguese breed. A feeding trial compared a conventional concentrate diet with a maize-based finishing diet, focusing on breast and thigh cuts. Key analyses included physical and chemical parameters, fatty acid composition and nutritional indices, highlighting implications for health and niche market potential. Thighs of birds fed on maize show higher post-mortem pH, independently of the fed type. These also have higher moisture levels. Protein levels are higher in the breast of concentrate-fed birds, and lower in the thighs of maize-fed birds. Thigh meat exhibited higher intramuscular fat. Thigh of concentrate-fed birds have higher water-holding capacity, and breast of concentrate-fed birds have lower water-holding capacity. Breast meat had elevated levels of long-chain polyunsaturated fatty acids (PUFAs). Maize-fed birds showed higher levels of plant-based FAs, while concentrate-fed birds demonstrated increased PUFAs such as EPA and DHA. Meat cuts affect firmness and colour attributes, with thighs displaying higher colour attributes and firmness levels. Different cuts and feed influence *Branca* chicken meat's quality and properties, emphasising the importance of tailored diets and sensory analyses to enhance its nutritional profile, market differentiation, and consumer appeal.

1. Introduction

Chicken domestication began in South Asia (Lawal and Hanotte, 2021) and has led to the development of the most widespread form of livestock globally distributed livestock species, largely due to the dietary importance of eggs and meat (Borisova et al., 2021). Over time, poultry production systems have adapted to regional environmental conditions, cultural practices, and available resources (Dal Bosco et al., 2021; Sponenberg et al., 2019)., resulting in numerous breeds shaped by human selection (Sponenberg et al., 2017). Portuguese indigenous

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https://doi.org/10.1016/j.livsci.2026.105923
Received 22 January 2025; Received in revised form 11 February 2026; Accepted 16 February 2026
Available online 16 February 2026

breeds such as *Pedrês Portuguesa, Amarela*, and *Preta* were standardised in 2003, with *Branca* following in 2010 (da Costa Soares, 2015).

Industrialised production systems have centralised resources and enable the growth of multinational corporations, causing breed specialisation and the decline of many local breeds (Sponenberg et al., 2019). This threatens local genetic diversity, increasing the risk of biodiversity loss, and has led European countries, including Portugal, to implement conservation policies (Sponenberg et al., 2019). Despite the dominance of industrial systems, family farming remains significant worldwide (Besbes et al., 2007). In developing countries, local breeds account for 95 % of poultry and thrive in scavenging systems (Besbes et al., 2007; Mata and Mwakifuna, 2012). In developed countries, including Portugal, traditional farming persists, supported by beliefs in superior quality, organic practices, and animal welfare (Besbes et al., 2007; Meira et al., 2023). The *Branca* breed, a dual-purpose chicken, farmed in northern Portugal (Meira et al., 2022), represents a valuable genetic and cultural resource with productive potential under small-scale farming conditions (Soares et al., 2023). These slow-growing breeds perform similarly to other European local breeds in small-scale systems (Soares et al., 2015).

The appreciation of local products has enhanced the popularity of niche items. These low-input, less productive systems align with modern consumer preferences for authentic flavours and genuine products (Soares et al., 2023). (Escobedo del Bosque et al., 2022; Franzoni et al., 2021; Meira et al., 2023; Soares et al., 2023). This trend has drawn attention to preserving local breeds, increasing producer participation and scientific interest (Brito et al., 2021). The meat of the *Branca* chicken is renowned for its texture, flavour, and colour, features in Portuguese traditional and regional cuisine (Brito et al., 2018).

Poultry meat is widely recognised for its high nutritional value, particularly due to its high-quality protein, content of unsaturated fatty acids (Dal Bosco et al., 2012; Sokołowicz et al., 2016). While native breeds grow more slowly than commercial lines, their meat is healthier, offering higher protein, less fat, and more n-3 polyunsaturated fatty acids (PUFA), appealing to specific consumers (Dal Bosco et al., 2012; Pellattiero et al., 2020). Meat quality is influenced by multiple intrinsic and extrinsic factors, including technological traits and biochemical composition (Gálvez et al., 2020). Poultry nutrition significantly influences meat quality and safety, as dietary fatty acids directly impact tissue composition (Baéza et al., 2022).

Fatty acids play a role in various human diseases, particularly cardiovascular conditions, with saturated fatty acids (SFA) linked to negative health effects, while PUFA offer benefits (Perna and Hewlings, 2022). The fatty acid composition of poultry meat is important due to its significant contribution to consumer diets. Chicken breast meat, leaner than other meats, provides high-quality protein, mild flavour, and versatility, while skinless leg meat contains higher lipid levels (Dal Bosco et al., 2022).

The fatty acid profile of poultry meat is influenced by the bird's diet, making dietary modifications an effective method to increase PUFA content in chicken meat (Toomer et al., 2020). As seafood becomes costlier, poultry enriched with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) can serve as an alternative source for long-chain n-3 PUFA, potentially enhancing human dietary intake (Da Silva et al., 2024; Elkin and Harvatine, 2023; Moran et al., 2020).

Although local poultry breeds such as the Portuguese *Branca* chicken are valued for their cultural and gastronomic importance, scientific information regarding their meat quality and nutritional composition remains limited. This lack of knowledge restricts the validation and valorisation of products derived from this breed. Dietary manipulation is recognised as an effective strategy to modify poultry meat quality, yet the effects of traditional maize-based finishing diets commonly used in small-scale systems are poorly documented in slow-growing local breeds. Furthermore, muscle type influences lipid deposition and technological meat quality traits, but the interaction between feeding strategy and muscle type in Branca chickens remains unclear. Therefore, this study aimed to characterise the physicochemical and nutritional properties of the *Branca* chicken meat and to evaluate the effect of a conventional concentrate diet and a maize-based finishing diet on breast and thigh cuts, with particular emphasis on fatty acid composition and associated nutritional indices.

2. Materials and methods

2.1. Husbandry and collection of data

The birds used in this study were purchased from AMIBA, Associação de Criadores de Bovinos de Raça Barrosã, the institution responsible for the herd book of several livestock breeds, including the *Branca* chicken breed. The birds were vaccinated against Newcastle disease and the infectious bronchitis virus. The trial was implemented using N = 23 cockerels, induced with a starter. At day 13, n = 11 cockerels were randomly allocated to the ration-fed group, while the other n = 12 cockerels were randomly allocated to the maize-fed group. The birds were fed *ad libitum*, according to a plan, including a starter, a growing/finishing ration, and maize as presented in Table 1. The nutritional value of each of these feeds is presented in Table 2.

Each bird group was housed separately, but their management and husbandry conditions were kept identical. Both groups had a stocking density of 0.45 m^2 of shaded space per bird, supplemented with 0.9 m^2 of outdoor access per bird, totalling 1.35 m^2 of space per bird. The enclosures were timber-framed structures, partially roofed, with meshed wire sides. Environmental enrichment included perches, sand for dust bathing, and nesting areas. Feed and water were provided ad libitum throughout the trial period.

The birds were slaughtered at 195 days of age. They were mechanically stunned and subsequently killed through manual exsanguination by incising the carotid artery and jugular vein, a process lasting approximately 30 to 40 s. Afterwards, the birds were manually plucked following scalding, eviscerated, and chilled for 24 h at a temperature of 4 °C. The breast and thigh cuts were separated and subsequently analysed.

Despite the existence of pullets in the trial, for this study, we have analysed only the cockerel meat. The samples were prepared for analysis and labelled with tracking numbers to ensure that the laboratory staff remained unaware of their provenance.

2.2. Chemical analysis

2.2.1. Moisture and ashes

The measurement of ash and moisture content was conducted on both the breast and the thigh, despite the minimal variability between cuts, as indicated by the literature. Samples weighing 10 grams were taken from the cranial portion of the breast. The analysis was performed in duplicate.

Moisture values (%) were determined following the Portuguese standard NP 1614/2002 (Instituto Português da Qualidade, 2002a), following the drying method until a constant weight was achieved at 105 °C in an oven, as quantified using the ISO 1442:1997 (International Organization for Standardization, 1997) method.

Ash values (%) were determined following the Portuguese standard NP 1615/2002 (Instituto Português da Qualidade, 2002b). Ash content was estimated through incineration (Mufalha B150, Nabertherm, Germany) for 6 h at a temperature of 550 °C ± 25 °C, in line with the ISO 936:1998 (International Organization for Standardization, 1998) method.

2.2.2. pH

The pH determination was carried out using a portable CRISON electrode, model PH25+, equipped with a penetration probe, previously calibrated at pH 4.0 and 7.0, and following the ISO 2917:1999 (International Organization for Standardization, 1999) method. The pH

Table 1
Feeding plan for the two groups in the trial: maize (M) and ration (R) for the different ages in rows. The figures are presented as a percentage of the total feed.

Age (Days)	1-33		34-40		41-47		48-54		55-195	
Group	M	R	M	R	M	R	M	R	M	R
Starter	100	100	50	50	33.3	50				
Ration			50	50	33.3	50	33.3	66.7		100
Maize					33.3		67,7	33.3	100	

Table 2
Composition of the starter and ration used in the trial.

Nutrient	Starter	Ration
Net protein	16.5	16.0
Ashes	5.6	6.9
Net fat	4.8	5.5
Calcium	1.1	1.1
Cellulose	3.2	3.9
Phosphorus	0.5	0.48
Methionine	0.29	0.3
Sodium	0.13	0.18
Lysin	0.9	0.8

values were recorded at 5 h (pH-5) and 24 h (pH-24) post-slaughter in two prime cuts to analyse (breast and thigh). An incision was made in each cut, always in the same location, using a scalpel. The electrode was inserted, and the value was recorded. The measurements were performed in triplicate.

2.2.3. Protein and fat profile determination

The protein determination adhered to the standards recommended by ISO 937:1978 (International Organization for Standardization, 1978).

The determination of total lipids was carried out using a 50 g sample of minced meat from each cut (breast and thigh), following the procedure of Bligh and Dyer (1959). Subsequently, fatty acids were determined according to the gas chromatography methodology described by Shehata et al. (1970) and Lorenzo et al. (2015). The separation and quantification of fatty acids were performed following Domínguez and Lorenzo (2014).

The following nutritional indices, applicable to meat, for the assessment of the fatty acid composition were calculated (Chen and Liu, 2020):

Polyunsaturated fatty acid/saturated fatty acid ratio (P/S) = (ΣPUFA / ΣSFA). The P/S ratio is a commonly employed indicator for evaluating dietary effects on cardiovascular health. The index is based on the premise that all PUFAs in the diet can reduce low-density lipoprotein cholesterol (LDL-C) and decrease serum cholesterol levels. At the same time, SFAs are associated with elevated serum cholesterol levels. Consequently, a higher P/S ratio is considered to have a more beneficial impact on cardiovascular health (Chen and Liu, 2020).

Index of atherogenicity (IA) = [C12:0 + (4 × C14:0) + C16:0] / ΣUFA. Ulbricht and Southgate (1991) introduced this index to assess the atherogenic potential of fatty acids (FAs), referring to their ability to promote lipid adhesion to cells within the circulatory and immune systems. As a result, consuming foods or products with a lower atherogenic index (IA) may help decrease total cholesterol and LDL-C levels in human blood plasma.

Index of thrombogenicity (IT) = (C14:0 + C16:0 + C18:0) / [(0.5 × ΣMUFA) + (0.5 × Σn-6 PUFA) + (3 × Σn-3 PUFA) + (n-3 / n-6)]. Ulbricht and Southgate (1991) also developed the IT index, which evaluates the potential of FAs to promote blood clot formation within vessels. Consequently, consuming foods or products with a lower IT benefits cardiovascular health. hypocholesterolemic / Hypercholesterolemic ratio (h/H) = (cis-C18:1 + ΣPUFA) / (C12:0 + C14:0 + C16:0). The h/H index was developed by Santos-Silva et al. (2002) to assess the effect of the FA composition on cholesterol. Higher h/H benefits human cardiovascular health.

Unsaturation index (UI) = 1 × (% monoenoics) + 2 × (% dienoics) + 3 × (% trienoics) + 4 × (% tetraenoics) + 5 × (% pentaenoics) + 6 × (% hexaenoics). The UI indicates the degree of unsaturation in lipids. Higher h/H benefits human cardiovascular health (Logue et al., 2000).

2.3. Physical analysis

2.3.1. Colour

The colour measurements were performed on both cuts (breast and thigh) 24 h post-slaughter. A DR-400 colourimeter (Konica Minolta, Osaka, Japan) with D65 illuminance equipped with an 8 mm diameter measurement area was used. Results were obtained in terms of lightness (L*), redness (a*), and yellowness (b*) indices according to the CIELAB (Commission Internationale de l'Éclairage) colour space. The calibration was executed using a standard white plate (L*=97.06; a*=5.28; b*= -3.49).

2.3.2. Water holding capacity, texture

The water holding capacity cooking loss (WHC CL) was calculated based on water loss during cooking. The breast samples (major pectoral muscle) were cooked following the procedure described by Pateiro et al. (2013).

For texture analysis, the samples were cut perpendicularly to the direction of the muscle fibres to create the cores to test. The Warner-Bratzler meat shear test for tenderness was conducted also following the methodology of Pateiro et al. (2013). A texture analyser (TA.XT.plus, Stable Micro Systems, Vienna Court, UK), was used in the procedure.

2.4. Statistical analysis

The data analysis was conducted using full factorial ANOVAs type III. Post hoc comparisons were carried out using the least significant differences (LSD) test, given that each factor included no more than three levels. To ensure the validity of the ANOVA assumptions, Levene's test was applied to verify the homogeneity of variances, while the Shapiro-Wilks test assessed the normality of the residuals. The statistical analysis was performed using IBM Corp.® SPSS® software, version 29.0.2.0 (2020), Armonk, NY, USA.

3. Results

The ANOVA tests applied to different meat chemical components revealed significant differences for fat (F=45.2, 4 df, $p < 0.001$), protein (F=9991.6, 4 df, $p < 0.001$), ash (F=227, 12 df, $p < 0.001$), pH-5 (F=502.3, 4 df, $p < 0.001$), and pH-24 (F=404, 4 df, $p < 0.001$) depending on the type of feed and the meat cut. The results are summarised in Table 3.

In terms of pH, the feed type has no effect. However, the cut influences pH, with the breast showing lower values than the thigh. As interactions are significant, it is observed that in birds fed on maize or concentrate, the pH is higher in the thighs. The variability is similar in the pH measured at 5 and 24 h post-mortem. The moisture content of the meat follows a similar trend to pH, being lower in the breasts of birds fed on concentrate and higher in the thighs of birds fed on maize. The fat content is higher in the thighs than in the breast cuts. The protein

Table 3
Mean results of the *Branca* chicken meat chemical composition for the different types of feed (maize and concentrate) and cuts (breast and thigh). The significant differences were tested with full factorial ANOVAs. The homogeneity of variances was confirmed via Levene's test (p>0.05). The normal distribution of the residuals was confirmed via the Shapiro-Wilks test (p>0.05). When the interaction is significant we disregard the main effects of the factors.

	pH-5	pH-24	Moisture	Fat	Protein	Ash
Feed				p>0.05		p>0.05
Maize				2.985		1.117
Concentrate				2.405		1.116
Cut				p<0.001		p>0.05
Breast				0.880		1.117
Thigh				4.510		1.117
Feed × **Cut**	p<0.01	p<0.01	p<0.01	p>0.05	p<0.001	p>0.05
Maize × Breast	5.76[a]	5.63[a]	74.58[b]	1.179	23.220[c]	1.120
Maize × Thigh	6.27[b]	6.12[b]	76.01[c]	4.790	19.873[a]	1.115
Concentrate × Breast	5.98[a]	5.73[a]	72.74[a]	0.580	24.681[d]	1.113
Concentrate × Thigh	6.27[b]	6.12[b]	75.03[b]	4.230	20.873[b]	1.119

Notes: WHC – water holding capacity after cooking; pH-5 – pH 5 h post-mortem; pH-24 – pH 24 h post-mortem. Unit of measurement for moisture, fat, protein, and ash – percentage. Fat refers to intramuscular fat present in meat.

content is lower in the thighs of birds fed on maize, whereas higher values are observed in the breasts of birds fed on concentrate. The ash content is unaffected by both the feed type and the cut.

The ANOVA tests applied to different meat physical properties revealed significant differences for WHC CL after cooking (F=145.55, 4 df, $p < 0.001$), firmness (F=199.5, 4 df, $p < 0.001$), work (F=308.5, 4 df, $p < 0.001$), shear force (F=227, 4 df, $p < 0.001$), lightness (F=389, 4 df, $p < 0.001$), yellowness (F=586, 4 df, $p < 0.001$), and redness (F=227, 4 df, $p < 0.001$) depending on the type of feed and the meat cut. The results are summarised in Table 4. The ANOVA tests applied to different fatty acids are summarised in Table 5.

In terms of WHC CL, the breasts of birds fed on concentrate show lower values compared to the other combinations of cuts and feed. Meat firmness is higher in the thighs than in the breasts. The thigh meat of birds fed on concentrate demonstrates greater firmness, whereas lower values are observed in the breast meat of these birds.

The work required to cut a core of meat is higher in birds fed on maize, with thighs requiring more effort than breasts. Higher levels of work are needed to cut cores from the thigh meat of birds fed on maize, while the opposite is observed in the breast meat of birds fed on concentrate. Following the classification proposed by Owens et al. (2004), the breast is classified as 'very tender', and the thigh as 'moderately tender'. Thighs of birds fed on maize are classified as 'slightly tender'.

Shearing force levels are consistently higher in thighs, regardless of the feed type, and lower in birds fed on concentrate. Regarding colour space indices, lightness is higher in breasts, while redness and yellowness are more pronounced in the meat of birds fed on maize and in breasts.

The fatty acid classification and the associated indices are presented in Table 6.

In terms of fatty acid profiles and the type of feed, maize-fed birds exhibit higher concentrations of C13:0, C14:1n-5, C20:0, C16:1n-7, and C20:3n-6 in their meat. Conversely, concentrate-fed birds show higher levels of C8:0, C10:0, C12:0, C17:0, C18:2n-6, C20:0, C20:1n-9, C20:2n-6, ETE, EPA, C22:2n-6, DHA, and C23:0 in their meat.

Regarding the type of cut, thigh meat contains higher levels of C12:0, C14:0, C15:0, C16:1n-7, C17:0, C18:0, C18:1n-9, C18:2n-6, C18:3n-3, C18:3n-6, ETE, and C23:0, whereas breast meat shows higher concentrations of C20:3n-6, C21:0, C22:0, DPA, and DHA.

Thighs from concentrate-fed birds contain higher levels of C12:0 and C18:3n-3, while breasts from maize-fed birds have lower levels of these fatty acids. Thighs from maize-fed birds exhibit lower levels of C22:1n-9 compared to all other combinations of meat cut and feed. Additionally, thighs from concentrate-fed birds show higher levels of C23:0, whereas breasts from maize-fed birds display the lowest levels of this fatty acid.

Concerning fatty acid associations, maize-fed birds exhibit higher levels of MUFA, while concentrate-fed birds show higher levels of PUFA, UFA, and total FA. Thigh meat contains higher levels of all fatty acid associations, including SFA, MUFA, PUFA, UFA, total FA, and IMF.

Regarding fatty acid indices, maize-fed birds and breast meat display higher IA values, whereas concentrate-fed birds and thighs exhibit higher P/S, h/H, and UI values. Specifically for UI, the thighs of concentrate-fed birds have the highest values, while the thighs and breasts of maize-fed birds show lower values.

4. Discussion

The results indicate that the bird feed type does not affect the pH of the meat post-mortem, aligning with findings that dietary manipulation

Table 4
Mean results of the *Branca* chicken meat physical properties for the different types of feed (maize and concentrate) and cuts (breast and thigh). The significant differences were tested with full factorial ANOVAs. The homogeneity of variances was confirmed via Levene's test (p>0.05). The normal distribution of the residuals was confirmed via the Shapiro-Wilks test (p>0.05). When the interaction is significant we disregard the main effects of the factors.

	WHC CL	Firmness	Work	SF	L*	a*	b*
Feed		p>0.05	p<0.01		p>0.05	p<0.001	p<0.01
Maize		6.80	104.81		19.67	20.01	17.22
Concentrate		6.81	88.51		16.75	15.40	13.705
Cut		p<0.05	p<0.001		p<0.001	p<0.001	p<0.001
Breast		5.66	61.00		20.86	20.375	19.025
Thigh		7.95	132.32		15.58	15.035	11.900
Feed × **Cut**	p<0.05	p>0.05	p>0.05	p<0.05	p>0.05	p>0.05	p>0.05
Maize × Breast	16.89[b]	6.704[b]	65.37	1.996[b]	22.83	22.53	21.83
Maize × Thigh	15.88[b]	6.888[b]	144.27	2.642[c]	16.54	17.49	12.61
Concentrate × Breast	11.65[a]	4.609[a]	56.65	1.383[a]	18.89	18.22	16.22
Concentrate × Thigh	17.48[b]	9.013[c]	120.39	2.941[c]	14.61	12.58	11.19

Notes: WHC CC– water holding capacity cooking loss, L* - Lightness,a* - Redness, b* - Yellowness. Unit of measurement: Firmness – kg/s, Total work – N/mm, Shear force – kgf/cm^2, WHC CL - %.

Table 5
Mean results of the fatty acid composition of the *Branca* chicken intramuscular meat fat for the different types of feed (maize and concentrate) and cuts (breast and thigh). The significant differences were tested with full factorial ANOVAs. The homogeneity of variances was confirmed via Levene's test (p>0.05). The normal distribution of the residuals was confirmed via the Shapiro-Wilks test (p>0.05). When the interaction is significant we disregard the main effects of the factors.

Fatty acid	ANOVA F-test			Grand		Feed			Cut			Feed × Cut			
	Value	df	p	mean	p	M	C	p	B	T	p	M × B	M × T	C × B	C × T
C4:0	324	4	***	0.045	NS			NS			NS				
C6:0	317	4	***	0.018	NS			NS			NS				
C8:0	351	4	***	0.019	*	0.018	0.020	NS			NS				
C10:0	722	4	***	0.013	*	0.012	0.013	NS			NS				
C11:0	309	4	***	0.006	NS			NS			NS				
C12:0	745	4	***	0.033							**	0.021[a]	0.024[a]	0.037[b]	0.048[c]
C13:0	128	4	***	0.004	*	0.0045	0.0036	NS			NS				
C14:0	372	4	***	0.368	NS			**	0.336	0.400	NS				
C14:1n-5	64	4	***	0.041	***	0.055	0.028	NS			NS				
C15:0	333	4	***	0.071	NS			*	0.066	0.076	NS				
C16:0	901	4	***	16.88	NS			NS			NS				
C16:1n-7	66	4	***	1.624	***	2.308	0.940	*	1.373	1.874	NS				
C17:0	289	4	***	0.132	***	0.115	0.149	**	0.119	0.146	NS				
C18:0	432	4	***	7.265	NS			*	6.821	7.710	NS				
9t-C18:1	699	4	***	0.060	***	0.068	0.051	NS			NS				
C18:1n-7	468	4	***	1.849	***	2.096	1.602	NS			NS				
C18:1n-9	294	4	***	27.66	NS			*	25.82	29.50	NS				
C18:2n-6	625	4	***	22.67	***	17.80	27.53	***	20.46	24.87	NS				
C18:3n-3	285	4	***	0.452							*	0.246[a]	0.305[a]	0.527[b]	0.728[c]
C18:3n-6	219	4	***	0.105	NS			**	0.094	0.116	NS				
CLA	824	4	***		NS			NS			NS				
C20:0	159	4	***	0.137	***	0.111	0.164	NS			NS				
C20:1n-9	188	4	***	0.307	*	0.283	0.332	NS			NS				
C20:2n-6	441	4	***	0.262	***	0.217	0.308	NS			NS				
ETE	256	4	***	0.020	***	0.014	0.026	**	0.017	0.022	NS				
C20:3n-6	210	4	***	0.236	***	0.280	0.193	**	0.265	0.208	NS				
C20:4n-6	44	4	***	3.508	NS			*	4.324	2.692	NS				
EPA	160	4	***	0.037	***	0.032	0.043	NS			NS				
C21:0	143	4	***	0.048	NS			*	0.052	0.043	NS				
C22:0	162	4	***	0.033	NS			*	0.037	0.030	NS				
C22:1n-9	537	4	***	0.031							**	0.033[b]	0.028[a]	0.030[b]	0.034[b]
C22:2n-6	378	4	***	0.034	***	0.029	0.039	NS			NS				
DPA	59	4	***	0.455	NS			***	0.584	0.326	NS				
DHA	37	4	***	0.286	**	0.203	0.370	***	0.394	0.178					
C23:0	378	4	***	0.015							***	0[a]	0.017[b]	0.019[c]	0.023[d]
C24:0	394	4	***	0.063	NS			NS			NS				

Notes: CLA – conjugated linolenic acid 9c,11t-C18:2; ETE - Eicosatrienoic Ω-3 fatty acid C20:3n-3; EPA - Eicosapentaenoic Ω-3 fatty acid C20:5n-3; DPA – Docosapentaenoic Ω-3 fatty acid C20:5n-3; DHA – Docosahexaenoic Ω-3 fatty acid C22:6n-3. p – p-value, df – degrees of freedom, M – Maize, C – Concentrate, B – Breast, T – Thigh. Significance levels of the F test: NS – Non-significant, * p<0.05, **p<0.01, ***p<0.001. Different letters in superscript indicate significant differences (p<0.05). IMF – Intramuscular fat. Significance levels of the factors and interaction F-tests: NS – Non-significant, * p<0.05, **p<0.01, ***p<0.001. Different letters in superscript indicate significant differences (p<0.05).

Table 6
Mean results of the fatty acid classification and association indices for the *Branca* chicken intramuscular meat fat in the different types of feed (maize and concentrate) and cuts (breast and thigh). The significant differences were tested with full factorial ANOVAs. The homogeneity of variances was confirmed via Levene's test (p>0.05). The normal distribution of the residuals was confirmed via the Shapiro-Wilks test (p>0.05).

Fatty acid	ANOVA F-test			Grand	Feed			Cut			Feed × Cut				
	Value	Df df	p	mean	p	M	C	p	B	T	p	M × B	M × T	C × B	C × T
SFA	1929	4	***	25.25	NS			*	24.41	25.90	NS				
MUFA	284	4	***	31.57	*	33.98	29.16	*	29.41	33.74	NS				
PUFA	1205	4	***	28.13							*	22.70[a]	23.13[a]	31.14[b]	35.53[b]
UFA	1323	4	***	59.70	**	56.89	62.50	**	56.33	63.07	NS				
Total FA	1457	4	***	84.85	*	82.23	87.47	***	80.74	88.96	NS				
n-3/n-6	238	4	***	23.07	NS			***	19.25	26.90	NS				
IMF	49	4	***	3.923	NS			***	2.316	5.531	NS				
P/S	953	4	***	1.122	***	0.909	1.335	NS			NS				
h/H	1731	4	***	3.353	***	3.056	3.651	**	3.227	3.480	NS				
IA	1634	4	***	0.310	***	0.333	0.287	**	0.321	0.299	NS				
IT	826	4	***	0.444	NS			***	0.003	0.054	NS				
UI	3169	4	***	98.08							*	89.55[a]	89.30[a]	102.27[b]	111.21[c]

Notes: p – p-value, df – degrees of freedom, M – Maize, C – Concentrate, B – Breast, T – Thigh. Significance levels of the F test: NS – Non-significant, * p<0.05, **p<0.01, ***p<0.001. Different letters in superscript indicate significant differences (p<0.05). IMF – Intramuscular fat. Significance levels of the factors and interaction F-tests: NS – Non-significant, * p<0.05, **p<0.01, ***p<0.001. Different letters in superscript indicate significant differences (p<0.05). SFA – Saturated fatty acids, MUFA – Monounsaturated fatty acids, PUFA – Polyunsaturated fatty acids, UFA Unsaturated fatty acids. P/S – Polyunsaturated fatty acid/saturated fatty acid ratio. h/H: hypocholesterolemic/hypercholesterolemic ratio. IA – index of atherogenicity. IT – index of thrombogenicity. UI – Unsaturation index.

often has minimal impact on the ultimate pH of poultry meat (Mir et al., 2017a; Semwogerere et al., 2019a; Sokanyile et al., 2016). However, the observed variation in pH between breast and thigh cuts was also reported by Liu et al. (2023) and is consistent with the understanding that differences in muscle fibre type between these cuts contribute to variations in post-mortem pH. Breast muscles, being predominantly fast-twitch fibres, are more prone to glycolytic metabolism, resulting in lower pH values compared to the slow-twitch fibres of thigh muscles (Ismail and Joo, 2017).

The observation that pH values are higher in thighs irrespective of feed type is also supported by the fact that thigh muscles tend to retain higher pH due to their differing metabolic profiles. Additionally, the consistency of pH variability at both five and 24-hour post-mortem aligns with findings suggesting that initial post-mortem pH trends are often sustained over time (Baldi et al., 2020). The results obtained in the present study for pH are similar to those obtained by Meira et al. (2022) with the same breed. The trend in moisture content, where thighs of birds fed on maize have higher water content, is corroborated by studies attributing this to the higher lipid and connective tissue content in thigh muscles, which influences water retention (Noh et al., 2023), which is also observed in the present study. The significantly lower moisture content in the breasts of birds fed on concentrate could be explained by reports that diets rich in concentrate often reduce water-holding capacity in poultry meat due to altered muscle fibre structure (Ismail and Joo, 2017; Listrat et al., 2016a).

The higher fat content in thighs compared to breasts agrees with the findings that thigh muscles naturally accumulate more intramuscular fat due to their metabolic profile (Cui et al., 2018; Liu et al., 2016). Moreover, diets rich in maize have been shown to influence fat deposition patterns in poultry, differentiating intramuscular fat deposition in thighs and in the breast (Hrdinka et al., 1996). Also, being the breast muscle with high glycolytic activity, prepared for quick and short efforts such as flying, it is expected to display reduced development of IMF (Hocquette et al., 2010).The results showing higher protein content in the breast of birds fed on concentrate align with observations that concentrate-based diets, often richer in protein and amino acids than maize-based diets, enhance protein synthesis (Kidd et al., 2021; Macelline et al., 2021). The higher protein content in breast meat is also consistent with the muscle composition differences, where breast muscles are more protein-dense than thigh muscles (Chen et al., 2015; Panpipat et al., 2022). Conversely, the lower protein levels in the thighs of maize-fed birds may be explained by the notion that carbohydrate-rich diets such as maize may prioritise energy storage over protein deposition (Chang et al., 2023).

Ash content largely reflects mineral content, which tends to remain constant across different feeding regimes and cuts unless specifically altered through dietary mineral supplementation. The results obtained were similar to those obtained by Meira et al. (2022), for the same breed.

The lower WHC CL values observed in the breasts of birds fed on concentrate may be attributed to lower glycogen reserves in breast muscles due to the diet. Reduced glycogen levels lead to altered post-mortem pH decline, impacting the muscle's ability to retain water (Berri et al., 2015; Le Bihan-Duval et al., 2008).

The increased firmness in the thighs of concentrate-fed birds may be linked to higher IMF, contributing to thicker muscle fibres (Weng et al., 2022). The higher WHC CL in thighs also improves firmness (Mir et al., 2017b). The increased energy required for thighs may reflect their higher IMF content and greater structural density, containing higher levels of collagen, when compared to breasts, corroborating findings by Chen et al. (2015). Shearing force, consistently higher in thighs regardless of feed type, reflects the inherent structural differences between thigh and breast muscles. Thigh muscles' oxidative nature and connective tissue density contribute to their resistance to shearing (Chen et al., 2015). The breast has, therefore, a more tender texture than the thighs.

The observed higher lightness (L*) in breasts compared to thighs aligns with established findings that oxidative muscle fibres, predominant in thighs, lead to higher myoglobin content, contributing to a higher degree of light absorbance and, therefore, lower reflectance resulting in darkness in colour (Ruedt et al., 2023). The pronounced redness (a*) and yellowness (b*) in maize-fed birds and in breasts could be attributed to dietary pigments in maize, such as xanthophylls, which influence meat colouration (Smith et al., 2002; Wideman et al., 2016). The higher degree of redness in the breast is somehow unexpected, at least in comparison to other literature. The chilling of the carcasses for 24 h to 4 °C before the readings may explain these results as reported by Petracci and Fletcher (2002) in their experiment. In a study with the same breed, Meira et al. (2022), registered higher degrees of redness for thighs in comparison to breasts.

The FA profile of meat is a crucial determinant of its nutritional and sensory qualities (Semwogerere et al., 2019b). The results of this study, indicate that maize-fed birds exhibit higher concentrations of FA, including C13:0, C14:1n-5, C20:0, C16:1n-7, and C20:3n-6. In contrast, concentrate-fed birds have elevated levels of short-chain FA (C8:0, C10:0, and C12:0), PUFAs like C18:2n-6, C20:2n-6, ETE, EPA, and DHA, as well as long-chain SFA such as C23:0. These differences can be attributed to the FA profile of the feed. Maize, rich in linoleic acid (C18:2n-6) (Yururdurmaz and Yildiz, 2022) and other plant-based FAs, influences the synthesis of MUFAs and PUFAs. Concentrate feeds, typically formulated with added oils, protein-rich ingredients, and potentially marine-derived lipids (Gao et al., 2021), provide precursors for longer-chain PUFAs such as EPA and DHA (Cartoni Mancinelli et al., 2022). Dietary FA profiles directly impact the FA profile of poultry meat, as there is a limited de novo FA synthesis (Kouba and Mourot, 2011). Diets enriched with UFAs resulted in higher concentrations of PUFAs in poultry meat, and not so much in abdominal fat (Crespo and Esteve-Garcia, 2001).

This study also highlights significant FA differences between thigh and breast meat. Thigh meat contains higher levels of medium- and long-chain saturated fatty acids (e.g., C12:0, C14:0, C15:0, and C18:0), MUFAs (C18:1n-9), and PUFAs such as C18:2n-6 and C18:3n-3. In contrast, breast meat shows elevated concentrations of very long-chain fatty acids (e.g., C20:3n-6, C21:0, C22:0, DPA, and DHA) but lower overall levels of UFA. These variations can be attributed to differences in muscle fibre type and lipid metabolism between cuts. Thigh meat, composed primarily of oxidative muscle fibres, tends to accumulate more intramuscular fat and FA derived from de novo synthesis. Breast meat, which has a higher proportion of glycolytic fibres, preferentially incorporates dietary long-chain PUFAs. Oxidative muscles have a greater lipid storage capacity and turnover than glycolytic muscles (Brooks and Mercier, 1994; Listrat et al., 2016b). The results agree with those of other authors (Cortinas et al., 2004; Rymer and Givens, 2006) who have also found higher values of DPA and DHA in chicken breast meat.

Thighs from concentrate-fed birds have higher levels of C12:0 and C18:3n-3, while breasts from maize-fed birds exhibit lower concentrations of these FA. Additionally, thighs from maize-fed birds display reduced levels of C22:1n-9 compared to other combinations, and thighs from concentrate-fed birds show elevated C23:0 levels. The results highlight a synergistic effect of diet and muscle type on FA deposition. Dietary manipulation affects not only overall FA composition but also the partitioning of lipids within different muscle types (Bostami et al., 2017; Castellini et al., 2002; Kartikasari et al., 2012).

The thighs of concentrate-fed birds display the highest UI values, in agreement with their superior PUFA content. In contrast, the lower UI values in maize-fed birds and breast meat correlate with their higher SFA content. Maize-fed birds exhibit lipid profiles with higher MUFA and IA values, while concentrate-fed birds show elevated PUFA, UFA, and healthier fatty acid indices (P/S, h/H, UI) as a result. Additionally, the superior FA content and indices in thigh meat underline the influence of muscle type on lipid deposition.

5. Conclusion

This study analysed the influence of feed type and muscle type on the physicochemical and nutritional properties of the *Branca* cock meat. Muscle type was the primary factor affecting post-mortem pH, proximate composition, and lipid deposition, reflecting intrinsic differences in fibre composition and metabolic activity. Thigh meat showed higher pH, moisture, and lipid content, whereas breast meat presented higher protein levels and lower intramuscular fat. Finishing diet significantly influenced fatty acid composition, with maize-based diets increasing medium-chain saturated and monounsaturated fatty acids, while concentrate-based diets enhanced long-chain polyunsaturated fatty acids, including EPA and DHA. These findings demonstrate that dietary strategies can modulate the nutritional profile of meat in slow-growing local breeds. This study provides novel insights into the interaction between feeding strategy and muscle type in the Portuguese *Branca* chicken, addressing existing knowledge gaps regarding meat quality in this breed. Improved characterisation of these quality traits supports the sustainable utilisation of local genetic resources and may strengthen conservation efforts by increasing the economic value and production viability of traditional poultry systems.

Author statement

All procedures in this trial adhered to standard husbandry practices, eliminating any ethical concerns requiring review by an ethics committee. Research data is available upon request. To request the data, contact the corresponding author of the article. During the preparation of this work, the authors did not use IA tools.

Funding

This research was funded by the Instituto Politécnico de Viana do Castelo under grant number BI_01_2021_Raça Branca.

Disclosure statement

The authors report there are no competing interests to declare.

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Fernando Mata: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Joaquim Cerqueira:** Writing – review & editing, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **José Araújo:** Writing – review & editing, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **Preciosa Pires:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Jose Lorenzo:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Roberto Bermúdez:** Writing – review & editing, Methodology, Formal analysis. **Laura Soares:** Writing – review & editing, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interests

Acknowledgements

Centre for Research and Development in Agrifood Systems and Sustainability is supported by Fundação para a Ciência e a Tecnologia FCT, Portugal) (UIDB/05937/2020 DOI:10.54499/UIDB/05937/2020 and UIDP/05937/2020 DOI:10.54499/UIDP/05937/2020).

References

Baéza, E., Guillier, L., Petracci, M., 2022. Production factors affecting poultry carcass and meat quality attributes. Animal 16, 100331. https://doi.org/10.1016/j.animal.2021.100331.

Baldi, G., Yen, C.-N., Daughtry, M.R., Bodmer, J., Bowker, B.C., Zhuang, H., Petracci, M., Gerrard, D.E., 2020. Exploring the factors contributing to the high ultimate pH of broiler pectoralis major muscles affected by wooden breast condition. Front. Physiol. 11, 343. https://doi.org/10.3389/fphys.2020.00343.

Berri, C., Matayeur-Coustard, S., Lessire, M., Duval, E., Bouvarel, I., Duclos, M., Le Bihan-Duval, M., Tesseraud, S., 2015. Managing Poultry Meat Quality by Nutrition. In: 22nd European Symposium on the Quality of Poultry Meat. World's Poultry Science Association. Nantes.

Besbes, B., Tixier-Boichard, M., Hoffmann, I., Jain, G.L., 2007. Future trends for poultry genetic resources. In: Proceedings of the International Conference of Poultry in the 21st Century: Avian Influenza and Beyond, pp. 5–7.

Bligh, E.G., Dyer, W.J., 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. 37, 911–917. https://doi.org/10.1139/o59-099.

Borisova, V.L., Terentyev, S.E., Stefanova, I.L., Sazonova, E.A., Kramlikh, O.Y., 2021. Effective use of meat of meat-and-egg chicken and eggs for the production of specialized semi-finished products. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing, 012022.

Bostami, A., Mun, H., Yang, C., 2017. Breast and thigh meat chemical composition and fatty acid profile in broilers fed diet with dietary fat sources. J. Food Process Technol. 8, 1000672. https://doi.org/10.4172/2157-7110.1000672.

Brito, N. V, Gouveia, A., Leite, J., Ribeiro, V., Alves, M., Dantas, R., 2018. Galinhas de Portugal. Município de Ponte de Lima, Associação Concelhia das Feiras Novas, Associação dos Criadores de Bovinos de Raça Barrosa: Ponte de Lima, Portugal.

Brito, N.V, Lopes, J.C., Ribeiro, V., Dantas, R., Leite, J.V, 2021. Biometric characterization of the Portuguese autochthonous hens breeds. Animals 11, 498. https://doi.org/10.3390/ani11020498.

Brooks, G.A., Mercier, J., 1994. Balance of carbohydrate and lipid utilization during exercise: the" crossover" concept. J. Appl. Physiol. 76, 2253–2261. https://doi.org/10.1152/jappl.1994.76.6.2253.

Cartoni Mancinelli, A., Mattioli, S., Twining, C., Dal Bosco, A., Donoghue, A.M., Arsi, K., Angelucci, E., Chiattelli, D., Castellini, C., 2022. Poultry meat and eggs as an alternative source of n-3 long-chain polyunsaturated fatty acids for human nutrition. Nutrients 14, 1969. https://doi.org/10.3390/nu14091969.

Castellini, C., Mugnai, C., Dal Bosco, A., 2002. Effect of organic production system on broiler carcass and meat quality. Meat Sci. 60, 219–225. https://doi.org/10.1016/S0309-1740(01)00124-3.

Chang, C., Zhang, Q.Q., Wang, H.H., Chu, Q., Zhang, J., Yan, Z.X., Liu, H.G., Geng, A.L., 2023. Dietary metabolizable energy and crude protein levels affect pectoral muscle composition and gut microbiota in native growing chickens. Poult. Sci. 102, 102353. https://doi.org/10.1016/j.psj.2022.102353.

Chen, J., Liu, H., 2020. Nutritional indices for assessing fatty acids: a mini-review. Int. J. Mol. Sci. 21, 5695. https://doi.org/10.3390/ijms21165695.

Chen, Y., Qiao, Y., Xiao, Y., Chen, H., Zhao, L., Huang, M., Zhou, G., 2015. Differences in physicochemical and nutritional properties of breast and thigh meat from crossbred chickens, commercial broilers, and spent hens. Asian-Australas J. Anim. Sci. 29, 855–864. https://doi.org/10.5713/ajas.15.0840.

Cortinas, L., Villaverde, C., Galobart, J., Baucells, M.D., Codony, R., Barroeta, A.C., 2004. Fatty acid content in chicken thigh and breast as affected by dietary polyunsaturation level. Poult. Sci. 83, 1155–1164. https://doi.org/10.1093/ps/83.7.1155.

Crespo, N., Esteve-Garcia, E., 2001. Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens. Poult. Sci. 80, 71–78. https://doi.org/10.1093/ps/80.1.71.

Cui, H., Zheng, M., Zhao, G., Liu, R., Wen, J., 2018. Identification of differentially expressed genes and pathways for intramuscular fat metabolism between breast and thigh tissues of chickens. BMC Genomics 19, 1–9. https://doi.org/10.1186/s12864-017-4292-3.

da Costa Soares, M.L., 2015. Caracterização fenotípica e genotípica das raças autóctones de galináceos portugueses: Pedrês Portuguesa, Preta Lusitânica e Amarela. Instituto de Ciências Biomédicas Abel Salazar, Porto.

Da Silva, A., Cabrera, M.C., Olivero, R., del Puerto, M., Terevinto, A., Saadoun, A., 2024. The incorporation of Chia seeds (Salvia hispanica L.) in the chicken diet promotes the enrichment of meat with n-3 fatty acids, particularly EPA and DHA. Appl. Food Res. 4, 100416. https://doi.org/10.1016/j.afres.2024.100416.

Dal Bosco, A., Cartoni Mancinelli, A., Vaudo, G., Cavallo, M., Castellini, C., Mattioli, S., 2022. Indexing of fatty acids in poultry meat for its characterization in healthy human nutrition: a comprehensive application of the scientific literature and new proposals. Nutrients 14, 3110. https://doi.org/10.3390/nu14153110.

Dal Bosco, A., Mattioli, S., Cartoni Mancinelli, A., Cotozzolo, E., Castellini, C., 2021. Extensive rearing systems in poultry production: The right chicken for the right farming system. A review of twenty years of scientific research in Perugia University, Italy. Animals 11, 1281. https://doi.org/10.3390/ani11051281.

Dal Bosco, A., Mugnai, C., Ruggeri, S., Mattioli, S., Castellini, C., 2012. Fatty acid composition of meat and estimated indices of lipid metabolism in different poultry genotypes reared under organic system. Poult. Sci. 91, 2039–2045. https://doi.org/10.3382/ps.2012-02228.

Domínguez, R., Lorenzo, J.M., 2014. Effect of genotype on fatty acid composition of intramuscular and subcutaneous fat of Celta pig breed. Grasas y Aceites 65. https://doi.org/10.3989/gya.0234141 e037–e037.

Elkin, R.G., Harvatine, K.J., 2023. A review of recent studies on the enrichment of eggs and poultry meat with omega-3 polyunsaturated fatty acids: novel findings and

unanswered questions. Poult. Sci. 102938. https://doi.org/10.1016/j.psj.2023.102938.
Escobedo del Bosque, C.I., Grahl, S., Nolte, T., Mörlein, D., 2022. Meat quality parameters, sensory properties and consumer acceptance of chicken meat from dual-purpose crossbreeds fed with regional faba beans. Foods 11, 1074. https://doi.org/10.3390/foods11081074.
Franzoni, A., Gariglio, M., Castillo, A., Soglia, D., Sartore, S., Buccioni, A., Mannelli, F., Cassandro, M., Cendron, F., Castellini, C., 2021. Overview of native chicken breeds in Italy: small scale production and marketing. Animals 11, 629. https://doi.org/10.3390/ani11030629.
Gálvez, F., Domínguez, R., Maggiolino, A., Pateiro, M., Carballo, J., De Palo, P., Barba, F. J., Lorenzo, J.M., 2020. Meat quality of commercial chickens reared in different production systems: industrial, range and organic. Ann. Anim. Sci. 20, 263–285. https://doi.org/10.2478/aoas-2019-0067.
Gao, Z., Zhang, J., Li, F., Zheng, J., Xu, G., 2021. Effect of oils in feed on the production performance and egg quality of laying hens. Animals 11, 3482. https://doi.org/10.3390/ani11123482.
Hocquette, J.F., Gondret, F., Baéza, E., Médale, F., Jurie, C., Pethick, D.W., 2010. Intramuscular fat content in meat-producing animals: development, genetic and nutritional control, and identification of putative markers. Animal 4, 303–319. https://doi.org/10.1017/S1751731109991091.
Hrdinka, C., Zollitsch, W., Knaus, W., Lettner, F., 1996. Effects of Dietary Fatty Acid Pattern on Melting Point and Composition of Adipose Tissues and Intramuscular Fat of Broiler Carcasses. Poult. Sci. 75, 208–215. https://doi.org/10.3382/ps.0750208.
Instituto Português da Qualidade, 2002a. Norma Portuguesa (NP) 1614:2002. Carne e produtos cárneos. Determinação do teor de humidade – Método de referência.
Instituto Português da Qualidade, 2002b. Norma Portuguesa (NP) 1615:2002, Carnes e produtos cárneos. Determinação da cinza total. Método de referência.
International Organization for Standardization, 1999. ISO 2917:1999 Meat and meat products — Measurement of pH — Reference method.
International Organization for Standardization, 1998. ISO 936:1998 Meat and meat products — Determination of total ash.
International Organization for Standardization, 1997. ISO 1442:1997 Meat and meat products - Determination of moisture content - Reference method.
International Organization for Standardization, 1978. ISO 937:1978 Meat and meat products - Determination of nitrogen content - Reference method.
Ismail, I., Joo, S.-T., 2017. Poultry meat quality in relation to muscle growth and muscle fiber characteristics. Korean J. Food Sci. Anim. Resour. 37, 873. https://doi.org/10.5851/kosfa.2017.37.6.873.
Kartikasari, L.R., Hughes, R.J., Geier, M.S., Makrides, M., Gibson, R.A., 2012. Dietary alpha-linolenic acid enhances omega-3 long chain polyunsaturated fatty acid levels in chicken tissues. Prostaglandins Leukot. Essent. Fatty Acids 87, 103–109. https://doi.org/10.1016/j.plefa.2012.07.005.
Kidd, M.T., Maynard, C.W., Mullenix, G.J., 2021. Progress of amino acid nutrition for diet protein reduction in poultry. J. Anim. Sci. Biotechnol. 12, 45. https://doi.org/10.1186/s40104-021-00568-0.
Kouba, M., Mourot, J., 2011. A review of nutritional effects on fat composition of animal products with special emphasis on n-3 polyunsaturated fatty acids. Biochimie 93, 13–17. https://doi.org/10.1016/j.biochi.2010.02.027.
Lawal, R.A., Hanotte, O., 2021. Domestic chicken diversity: origin, distribution, and adaptation. Anim. Genet. 52, 385–394. https://doi.org/10.1111/age.13091.
Le Bihan-Duval, E., Debut, M., Berri, C.M., Sellier, N., Santé-Lhoutellier, V., Jégo, Y., Beaumont, C., 2008. Chicken meat quality: genetic variability and relationship with growth and muscle characteristics. BMC Genet 9, 1–6. https://doi.org/10.1186/1471-2156-9-53.
Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., Picard, B., Bugeon, J., 2016a. How muscle structure and composition influence meat and flesh quality. Sci. World J. 2016, 3182746. https://doi.org/10.1155/2016/3182746.
Listrat, A., Lebret, B., Louveau, I., Astruc, T., Bonnet, M., Lefaucheur, L., Picard, B., Bugeon, J., 2016b. How muscle structure and composition influence meat and flesh quality. Sci. World J. 2016, 3182746. https://doi.org/10.1155/2016/3182746.
Liu, J., Fu, R., Liu, R., Zhao, G., Zheng, M., Cui, H., Li, Q., Song, J., Wang, J., Wen, J., 2016. Protein profiles for muscle development and intramuscular fat accumulation at different post-hatching ages in chickens. PLoS One 11, e0159722. https://doi.org/10.1371/journal.pone.0159722.
Liu, L., Chen, Q., Yin, L., Tang, Y., Lin, Z., Zhang, D., Liu, Y., 2023. A comparison of the meat quality, nutritional composition, carcass traits, and fiber characteristics of different muscular tissues between aged indigenous chickens and commercial laying hens. Foods 12, 3680. https://doi.org/10.3390/foods12193680.
Logue, J.A., De Vries, A.L., Fodor, E., Cossins, A.R., 2000. Lipid compositional correlates of temperature-adaptive interspecific differences in membrane physical structure. J. Exp. Biol. 203, 2105–2115. https://doi.org/10.1242/jeb.203.14.2105.
Lorenzo, J.M., Fonseca, S., Gómez, M., Domínguez, R., 2015. Influence of the salting time on physico-chemical parameters, lipolysis and proteolysis of dry-cured foal "cecina. LWT-Food Sci. Technol. 60, 332–338. https://doi.org/10.1016/j.lwt.2014.07.023.
Macelline, S.P., Chrystal, P.V, Liu, S.Y., Selle, P.H., 2021. The dynamic conversion of dietary protein and amino acids into chicken-meat protein. Animals 11, 2288. https://doi.org/10.3390/ani11082288.
Mata, F., Mwakifuna, B., 2012. Comparative mortality and predation in relation to egg production traits of Rhode Island Red, Black Australorp and Hyblack laying hens in scavenging production systems of rural Malawi. Br. Poult. Sci. 53, 570–575. https://doi.org/10.1080/00071668.2012.736612.
Meira, M., Afonso, I.M., Casal, S., Lopes, J.C., Domingues, J., Ribeiro, V., Dantas, R., Leite, J.V, Brito, N.V, 2022. Carcass and meat quality traits of males and females of the "Branca" portuguese autochthonous chicken breed. Animals 12, 2640. https://doi.org/10.3390/ani12192640.
Meira, M., Afonso, I.M., Cruz, R., Lopes, J.C., Martins, R.S., Domingues, J., Ribeiro, V., Dantas, R., Casal, S., Brito, N.V, 2023. Carcass yields and meat composition of roosters of the portuguese autochthonous poultry breeds: "Branca","Amarela","Pedrês Portuguesa", and "Preta Lusitânica.". Foods 12, 4020. https://doi.org/10.3390/foods12214020.
Mir, N.A., Rafiq, A., Kumar, F., Singh, V., Shukla, V., 2017a. Determinants of broiler chicken meat quality and factors affecting them: a review. J. Food Sci. Technol. 54, 2997–3009. https://doi.org/10.1007/s13197-017-2789-z.
Mir, N.A., Rafiq, A., Kumar, F., Singh, V., Shukla, V., 2017b. Determinants of broiler chicken meat quality and factors affecting them: a review. J. Food Sci. Technol. 54, 2997–3009. https://doi.org/10.1007/s13197-017-2789-z.
Moran, C.A., Morlacchini, M., Keegan, J.D., Rutz, F., Fusconi, G., 2020. Docosahexaenoic acid enrichment of layer hen tissues and eggs through dietary supplementation with heterotrophically grown Aurantiochytrium limacinum. J. Appl. Poul. Res. 29, 152–161. https://doi.org/10.1016/j.japr.2019.10.002.
Noh, S.-W., Song, D.-H., Ham, Y.-K., Yang, N.-E., Kim, H.-W., 2023. Physicochemical properties of chicken breast and thigh as affected by sous-vide cooking conditions. Foods 12, 2592. https://doi.org/10.3390/foods12132592.
Owens, C.M., Cavit, L.C., Meullenet, J.-F.C., 2004. Tenderness evaluation in poultry meat. In: Proceeding of the 57th American Meat Science Association, Reciprocal Meat Conference, pp. 115–121.
Panpipat, W., Chaijan, M., Karnjanapratum, S., Keawtong, P., Tansakul, P., Panya, A., Phonsatta, N., Aoumtes, K., Quan, T.H., Petcharat, T., 2022. Quality characterization of different parts of broiler and Ligor hybrid chickens. Foods 11, 1929. https://doi.org/10.3390/foods11131929.
Pateiro, M., Lorenzo, J.M., Díaz, S., Gende, J.A., Fernández, M., González, J., García, L., Rial, F.J., Franco, D., 2013. Meat quality of veal: discriminatory ability of weaning status. Spanish J. Agric. Res. 11, 1044–1056. https://doi.org/10.5424/sjar/2013114-4363.
Pellattiero, E., Tasoniero, G., Cullere, M., Gleeson, E., Baldan, G., Contiero, B., Dalle Zotte, A., 2020. Are meat quality traits and sensory attributes in favor of slow-growing chickens? Animals 10, 960. https://doi.org/10.3390/ani10060960.
Perna, M., Hewlings, S., 2022. Saturated fatty acid chain length and risk of cardiovascular disease: a systematic review. Nutrients 15, 30. https://doi.org/10.3390/nu15010030.
Petracci, M., Fletcher, D.L., 2002. Broiler skin and meat color changes during storage. Poult. Sci. 81, 1589–1597. https://doi.org/10.1093/ps/81.10.1589.
Ruedt, C., Gibis, M., Weiss, J., 2023. Meat color and iridescence: origin, analysis, and approaches to modulation. Compr. Rev. Food Sci. Food Saf. 22, 3366–3394. https://doi.org/10.1111/1541-4337.13191.
Rymer, C., Givens, D.I., 2006. Effect of species and genotype on the efficiency of enrichment of poultry meat with n− 3 polyunsaturated fatty acids. Lipids 41, 445–451. https://doi.org/10.1007/s11745-006-5118-2.
Santos-Silva, J., Bessa, R.J.B., Santos-Silva, F., 2002. Effect of genotype, feeding system and slaughter weight on the quality of light lambs: II. Fatty acid composition of meat. Livest. Prod. Sci. 77, 187–194. https://doi.org/10.1016/S0301-6226(02)00059-3.
Semwogerere, F., Neethling, J., Muchenje, V., Hoffman, L.C., 2019a. Meat quality, fatty acid profile, and sensory attributes of spent laying hens fed expeller press canola meal or a conventional diet. Poult. Sci. 98, 3557–3570. https://doi.org/10.3382/ps/pez092.
Semwogerere, F., Neethling, J., Muchenje, V., Hoffman, L.C., 2019b. Meat quality, fatty acid profile, and sensory attributes of spent laying hens fed expeller press canola meal or a conventional diet. Poult. Sci. 98, 3557–3570. https://doi.org/10.3382/ps/pez092.
Shehata, A.Y., DeMan, J.M., Alexander, J.C., 1970. A simple and rapid method for the preparation of methyl esters of fats in milligram amounts for gas chromatography. Canadian Inst. Food Technol. J. 3, 85–89. https://doi.org/10.1016/S0008-3860(70)74286-4.
Smith, D.P., Lyon, C.E., Lyon, B.G., 2002. The effect of age, dietary carbohydrate source, and feed withdrawal on broiler breast fillet color. Poult. Sci. 81, 1584–1588. https://doi.org/10.1093/ps/81.10.1584.
Soares, L., Mata, F., Cerqueira, J.L., Araújo, J., 2023. Growing patterns of the branca chicken breed—concentrate vs. maize-based diet. Agriculture 13, 2282. https://doi.org/10.3390/agriculture13122282.
Soares, L.C., Lopes, J.C., Brito, N.V, Carvalheira, J., 2015. Growth and carcass traits of three Portuguese autochthonous chicken breeds: Amarela, Preta Lusitânica and Pedrês Portuguesa. Ital. J. Anim. Sci. 14, 3566. https://doi.org/10.4081/ijas.2015.3566.
Sokanyile, S., Chulayo, A.Y., Muchenje, V., 2016. Effect of phase feeding manipulation on colour coordinates and meat yield of broiler chickens. In: 62nd International Congress of Meat Science and Technology.
Sokołowicz, Z., Krawczyk, J., Świątkiewicz, S., 2016. 4. Quality of poultry meat from native chicken breeds – a review. Ann. Anim. Sci. 16, 347–368. https://doi.org/10.1515/aoas-2016-0004.
Sponenberg, D.P., Beranger, J., Martin, A., 2017. Managing breeds for a secure future: strategies for breeders and breed associations. 5m Books Ltd.
Sponenberg, D.P., Martin, A., Couch, C., Beranger, J., 2019. Conservation strategies for local breed biodiversity. Diversity 11, 177. https://doi.org/10.3390/d11100177.
Toomer, O.T., Livingston, M., Wall, B., Sanders, E., Vu, T., Malheiros, R.D., Livingston, K. A., Carvalho, L.V., Ferket, P.R., Dean, L.L., 2020. Feeding high-oleic peanuts to meat-type broiler chickens enhances the fatty acid profile of the meat produced. Poult. Sci. 99, 2236–2245. https://doi.org/10.1016/j.psj.2019.11.015.
Ulbricht, T.L.V, Southgate, D.A.T., 1991. Coronary heart disease: seven dietary factors. The Lancet 338, 985–992.

Weng, K., Huo, W., Li, Y., Zhang, Yu, Zhang, Yang, Chen, G., Xu, Q., 2022. Fiber characteristics and meat quality of different muscular tissues from slow- and fast-growing broilers. Poult. Sci. 101, 101537. https://doi.org/10.1016/j.psj.2021.101537.

Wideman, N., O'bryan, C.A., Crandall, P.G., 2016. Factors affecting poultry meat colour and consumer preferences-a review. Worlds Poult. Sci. J. 72, 353–366. https://doi.org/10.1016/0140-6736(91)91846-M.

Yururdurmaz, C., Yildiz, H., 2022. Fatty acid compositions of Zea mays L. varieties in Turkey. Prog. Nutr. 24, e2022112. https://orcid.org/0000-0001-5330-3388.